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Some Physical and Pasting Properties of Starch Isolated from Some Corn Genotypes Cultivated Under Sulaimani Governorate Condition

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Abstract

This research was carried out on ten corn genotypes by cultivated all of genotypes in the year 2020 in Qlyasan research station location of College of Agriculture Engineering Science in Sulaimani University to produce seeds. The seeds were cleaned and ground to extract the starch from corn genotypes with purifications starch by Proteinase-K enzyme to purify the extracted starch from the residues protein that are still present in the starch. All corn genotypes' physical and pasting characteristics has been studied in the lab, and statistically analyzed showed that there were substantial differences between all cornstarch genotypes. The physical properties included study these traits; starch granules distribution which maximum value recorded to medium as a percentage for all genotypes, maximum pH was 5.470, bulk density was 0.725 g/cm^3, and maximum value of phosphate was 0.0235 %. Also, a study includes syneresis % which increase gradually in values for all genotypes by storage time, turbidity characteristic which decrease gradually for all corn starch genotypes with period of storage and the elements of pasting properties which includes; past temperature record 85 C˚, Peak Viscosity which was 584667 AU, peak temperature more than 95 C˚, cool paste viscosity (CPV) recorded 1220.000 AU and final element which was setback viscosity which record 735.00 AU.

Key words: Cornstarch, granule size distribution, light transmittance, pasting properties and syneresis.

I. INTRODUCTION

Corn (*Zea mays* L.) holds a significant position among cereal crops worldwide. It belongs to the Poaceae family and ranks third in production after wheat and rice (Chaudhary *et al*., 2014). It can be utilized for several purposes especially for human food and different field of industry. On the other hand, it uses as an animal fodder. As it is known, corn contains high percentage of starch and considerable amount of oil and protein which make this crop one the most crops utilize for food industry. An excellent combination of high market demand with comparatively low production cost, assists to increase corn cultivation (Alnori and Ahmad, 2012; Sheikh Abdulla *et al*., 2022). In addition to being a vital staple, corn yields various valuable products, including cornstarch, glucose syrup, high fructose corn syrup, and dextrin. These products are used extensively, with applications ranging from animal and poultry feed to diverse industrial purposes (Gul *et al*., 2021). Notably, a substantial portion of the global starch supply, approximately 80%, is derived from corn (Jompuk *et al*., 2011). Corn starch serves as a cornerstone in the food industry, accounting for about 60% of its usage, while the remaining 40% caters to non-food applications. In the realm of food, corn starch plays multiple roles such as a thickener, binder, disruptor, stabilizer, and texture enhancer. Beyond edibles, it finds utility in non-food sectors like adhesive production, inert filler creation, ink manufacturing, and textile production. Furthermore, the cosmetic and pharmaceutical industries make use of cornstarch-based materials for their thickening,

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bulking, and humectant properties (Copeland *et al*., 2009; Pérez-Pacheco *et al*., 2014). In the context of starch composition, it consists of amylose, characterized by unbranched chains, and amylopectin, comprised of highly branched chains. The amylose content can vary from 20% to 35%, while amylopectin content ranges between 65% and 80% by weight, depending on the plant source (Marichelvam *et al*., 2019). Despite of the widespread cultivation of corn in Iraq, which grown for fodder purposes only and on the other hand, it contains a high percentage of starch, there is a dearth of information or research on the physical and pasting properties of its starch. This is particularly relevant given the substantial and its consequential importance in food industries and non-food purposes. Thus, undertaking research in this essential area becomes imperative to comprehensively understand the characteristics of corn starch. Therefore, this research aims to study some of the physical and pasting properties of some corn starches genotypes grown in Iraq.

II. MATERIALS AND METHODS

Materials

It was collected 10 genotypes of corn (*Zea mays*, L) to use in this research were; (Dracma, ZP.434*B, Al-Maha, Corpeto, Fajar -1-, Dhqan, Sara, MSI*B ZP.434*A, Bagdad -3-,) and all of these genotypes were obtained from the General Commission for Agricultural Research - Field Crops Research Section - Iraqi Ministry of Agriculture and Ministry of Agriculture in Kurdistan Region-Iraq. To produce adequate amount of seed, it was cultivated all the genotypes of maize in summer of 2019 in the agronomy field of Qlyasan research station/ Sulaimani University/ College of Agriculture Engineering Science.

Methods

Starch Isolation

About 750 grams of pure seeds were taken and ground by High Speed Multi-Function Mill (Model: BTB 1962/3, Germany), to obtain fine flour, then this flour was mixed with an amount of water to obtain a paste and placed in a clean cloth and squeezed to obtain the liquid, this process was repeated several times until the starch did not remain in the mixture. Then, the filtration process was carried out using a sieve with mesh sieve (75 µm) to separate the starch from the fibers. The mixture was centrifuged at 4000 rpm. for 20 min to separate the starch from non-starchy material such as protein and residues then the slurry wished by distillate water, this process was repeated several times and then the starch treated with microbial proteinase-k, its specific activity is 300 Umg^{-1} at pH 7.5 for 4 hours then the soluble protein was removed by centrifuge as above. This process was carried out twice time. The purified starch was dried for 24 h at 45°C (Grant, 1998; Sandhu *et al*., 2005).

Starch Granule Size Distribution %

The microscopic image was used to measure the granule size distribution, depending on their size visible under the microscope. Three categories for this properties which is divided to large granules (> 15 µm), medium (between 5-15 µm) and small (<5 µm) starch granules. (Ketthaisong *et al*., 2013). To determine the starch granule size percent distribution, the number of granules in the specified size range was divided by the total number of granules (Chisenga et al., 2019).

$$Starch\ granule\ size\ distrbution\ \% = \frac{N\ granule}{N\ sample} \times 100$$

while *N* is the number of granules

pH determination

The pH determination was conduct based on the method of Benesi, (2005) using Digital laboratory pH meter (Multi 350i-Germany).

Bulk density g/cm^3

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Bulk density of cornstarch was determined by weight specific amount of starch (g) which occupies $1cm^3$ (ml) of symmetrical cylinder according to Adeleke and Odedeji, (2010) method, then the bulk density was calculated by using the equation bellow.

$$\text{Bulk density } g.(cm^3)^{-1} = \frac{weight\ of\ sample}{volume\ of\ sample\ after\ tapping}$$

Total phosphate content determination %

Total phosphate content of samples was determined according to the method described by (Helrich, 1990) with some modifications, then phosphate percentage was calculated according to regression equation between absorbance and phosphate concentration as following:

Y (mg/g starch) =36.18368*A - 0.1393
A= absorbance at 400 nm

Syneresis %

It was conducted due to the way that was used by (Singh *et al*., 2006), with some modified in the weight, then the percentage of syneresis % is calculated by the following equation (Khouryieh *et al*., 2005):

$$\text{Synersis } \% = \frac{total\ weight\ of\ separated\ liquid\ (g)}{total\ weight\ of\ the\ gel\ sample\ (g)} \times 100$$

Turbidity or Light transmittance %

The method of Craig *et al*., (1989) was used to obtain on the value of turbidity or light transmittance for all suspensions of studied starch.

Starch pasting properties

Amylograph was used to draw the curve of cooking (rheological properties) starting with paste temperature ended to peak viscosity at cooling of corn starch pasties by using Barabender amylograph (PT-100/VA-VE, D-47055 Duisburg, Germany) according to (Merca and Juliano, 1981).

Statistical analysis

The data were analyzed with ANOVA and a posteriori tests (Duncan) in order to determine statistically significant differences ($p < 0.05$) among the samples, using the XLSTAT, version (2016. .02.28451) statistical software. Results were the average of three replications.

III. RESULTS AND DISCUSSION

Starch granule size distribution %

The differences between studied starches which isolated from different corn genotypes were significant in their granules volume distribution (Table 1). Among all starch samples, medium granules have the main portion to the total volumes which was 34.1 to 56.2 %, followed by large-granules which ranged from 26.666 to 50.334 %, and small 13.334 to 28.1 % granules. Al Maha genotype had the higher proportion of medium-granules, while, the largest proportion of large-granules was found in MSI*B, the results also, showed that Corpeto genotype contained the largest proportion of small size granules. There are some physical properties of starch can influence by the size of its granules since that will change the surface area of starch which may impact on its ability to adsorb the water. Swelling of starch granules followed by Paste temperature, may affect by the later properties. However, the starch slurry viscosity also will depend on the volume of starch granules (Tsakama *et al*., 2010). Finally, it can attribute the differences in the distribution of starch granule size to the interrupt between genotypes and environment that will influence on starch characteristics and its equalizing for specific industries (Singh *et al*., 2010; Mir *et al*., 2017).

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Table (1): shown the percentages of granules size distributions of cornstarch genotypes

Genotypes	Particle size %		
	Large	Medium	small
Sara	36.666^{e}±0.001	48.666^{b}±0.001	14.667^{h}±0.001
Al Maha	25.333^{i}±0.001	56.200^{a}±0.100	18.667^{f}±0.001
Fajr-1	35.666^{f}±0.001	43.100^{e}±0.100	21.333^{d}±0.001
Bagdad-3	40.033^{d}±0.058	42.667^{f}±0.001	17.334^{g}±0.001
ZP.434*A	40.334^{c}±0.001	36.666^{h}±0.001	23.100^{c}±0.100
ZP.434*B	33.334^{g}±0.001	46.667^{c}±0.001	20.100^{e}±0.100
MSI*B	50.333^{a}±0.001	37.073^{g}±0.064	13.334^{i}±0.001
Dhqan	40.666^{b}±0.001	34.100^{i}±0.100	25.334^{b}±0.001
Corpeto	26.666^{h}±0.001	45.334^{d}±0.001	28.100^{a}±0.100
Dracma	33.334^{g}±0.001	46.666^{c}±0.001	20.100^{e}±0.100

pH determination, bulk density (g/cm^3) and total phosphate content (%)

The pH determination values of corn genotypes' starch are shown in table (2) that ranged between 5.470 – 4.537 and varied among the corn genotypes starch. The maximum value of 5.470 was recorded by Fajr-1 genotype and the minimum value (4.537) was recorded by ZP.434*B. Due to its impact on product flavor, pH is a crucial indicator of the nutritional value of food (Oduro *et al*., 2001). There are few works in previous literatures on bulk density. The values of bulk densities are illustrating in (Table 2) that ranged from 0.725 to 0.618 g/cm^3. The highest value recorded by ZP434*B genotype which was 0.725 g/m^3 and followed by Dhqan genotype (0.696 g/cm^3). while the lowest value recorded by ZP.434*A genotype which was 0.618 g/m^3. There are no differences between Al Maha and Corpeto genotypes in their values, also, there is no difference between Bagdad-3 and MSI*B genotypes in their values. The degree of coarseness of the starch sample is determined by bulk density. For the phosphate content which present in (Table 2), there were difference between corn starch genotypes, ZP.434*A genotype recorded a maximum value which was 0.0235 %, while Dracma recorded the minimum value of 0.0104 % among corn starch genotypes. Corn starch had the least phosphate content among normal cereal's starches, therefore these results agree with (Chinnasamy *et al*., 2022; Lim *et al*., 1994) that they reported the minimum value of phosphate content in corn starch among all cereals. The researches emphasized that in isolated purified starch, it can find only phosphorous in a considerable amount because it covalently binds with starch chains (Mcintyre *et al*., 1990). The chemical structure of starch phosphate may impact on the physiochemical properties of starch especially its power of water absorption followed by increasing of granules volume (Zuluaga *et al*., 2007). On the other hand, it can say, that there is a role to play by agronomical circumstances, starch components and genetic factors for limiting the starch phosphorus percentage (Pineda-Gomez et al., 2021).

Table (2). show the means value of pH, bulk density and total phosphate for corn starch genotypes.

Genotypes	pH	bulk density (g/cm^3)	total phosphate content (%)
Sara	5.360 ±0.010^{c}	0.649±0.001^{g}	0.0192±0.000^{d}
Al Maha	5.263 ±0.015^{d}	0.667±0.001^{e}	0.0233±0.000^{b}

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Fajr-1	5.470 ±0.010[a]	0.670±0.002[d]	0.0142±0.000[h]
Bagdad-3	4.657 ±0.015[h]	0.658±0.001[f]	0.0159±0.000[f]
ZP.434*A	5.440 ±0.010[b]	0.618±0.001[h]	0.0235±0.000[a]
ZP.434*B	4.537 ±0.015[i]	0.725±0.001[a]	0.0149±0.000[g]
MSI*B	5.350 ±0.010[c]	0.658±0.002[f]	0.0142±0.000[h]
Dhqan	5.233 ±0.015[e]	0.696±0.002[b]	0.0197±0.000[c]
Corpeto	4.937 ±0.015[f]	0.668±0.002[e]	0.0172±0.000[e]
Dracma	4.747 ±0.015[g]	0.677±0.002[c]	0.0104±0.000[i]

Syneresis %

This property of cornstarch gel refers to the expulsion of water drops from it, either on its surface or within its structure, as a result of the retrogradation process, wherein starch chains come closer together (Otegbayo *et al*., 2014). A notable disparity in the percentage of syneresis within starch gels was observed among various corn cultivars during a 5-day storage period, as indicated in figure (1). Syneresis is undesirable phenomena in both food and non-food applications due to storage period for somewhat time causing decline of gel equality and that may permit to mold growth (Ali *et al*., 2016). Among the starch pastes, Bagdad-3 exhibited the highest syneresis value at 80.411%, while ZP.434 starch gel showed the lowest value of 75.467% on the initial storage day, as detailed in Figure 1. Al-Maha's starch matrix demonstrated a gradual increase in syneresis from 78.133% to 82.403%, whereas ZP.434A experienced a sharper rise from 75.467% to 85.907%, as reported by (Ali *et al*., 2016). The ordering of syneresis percentages across different corn starches was: ZP.434A > MSIB > Corpeto > Dracma > ZP.434*B > Dhqan > Sara > Fajr-1 > Bagdad-3 > Al-Maha. Structure of the network of starch gel and the rate of aggregate formation by amylose, percentage of gelatinized granules with transfer of amylose from the inner granule to the outer solution media, in addition to the temperature and time of cooking and storage are effective factors which were attributed to increase of syneresis. (Abegunde *et al*., 2013).

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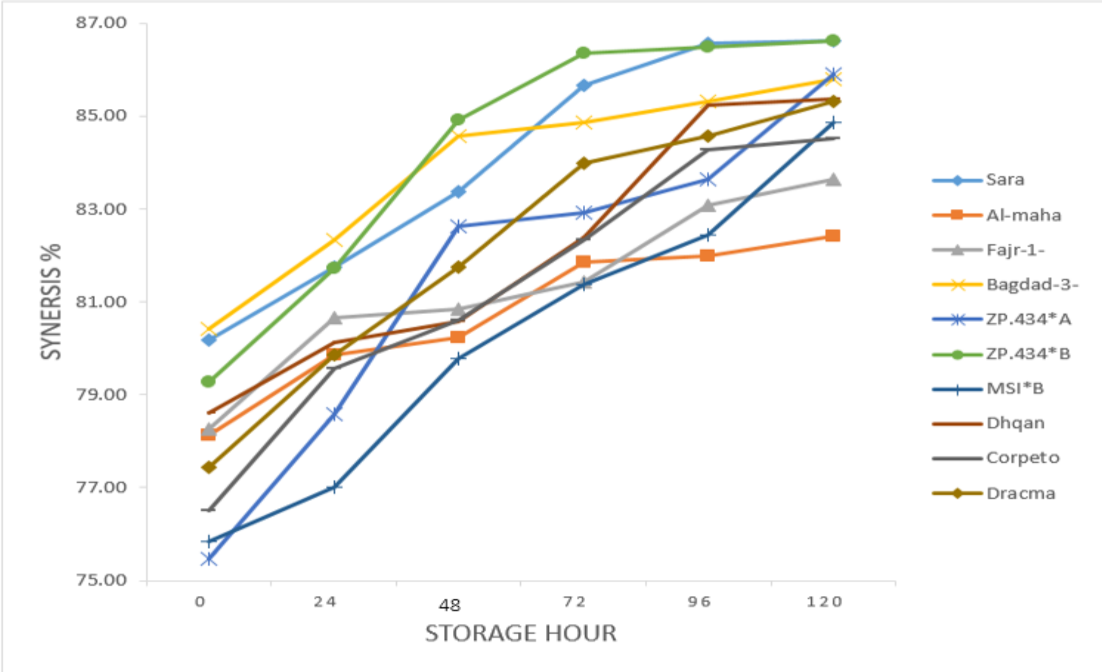

Figure (1). Effect of storage duration on synersis % for the corn starch genotypes

Light transmittance % or turbidity

In this test, all corn genotypes starches suspensions shown a considerable effect award light transmittance during storage periods at 4°C. The results figure (2) showed that there was a significant difference among the cornstarch samples. At 24 hours, light transmittance ranged from 40.746 to 63.981 %. After 5 days of storage, sharply decreasing from (64.576 and 58.790 %) to (29.800 and 24.122 %) in this properties took place in MSI*B and ZP.434*B genotypes respectively. On the other hand, at the same circumstance of storage, Dracma variety suspension had a maximum value of this criteria (52.855 %). A slight decreasing of this properties was happened in the other samples during the same period of storage. These results agreed with (Amoo *et al*., 2014; Simi and Abraham, 2008). Sandhu and Singh (2007) also reported that the storage of cornstarch suspensions increased their turbidity. The amount of swollen starch granules is the most factor may effect on absorb or pass or reflect the light which the rate of each one of them will determine the value of this properties (Mahto and Das, 2014). It was observed that a decrease of rice and corn starches suspensions clarity after period of storage (Ali *et al*., 2016).

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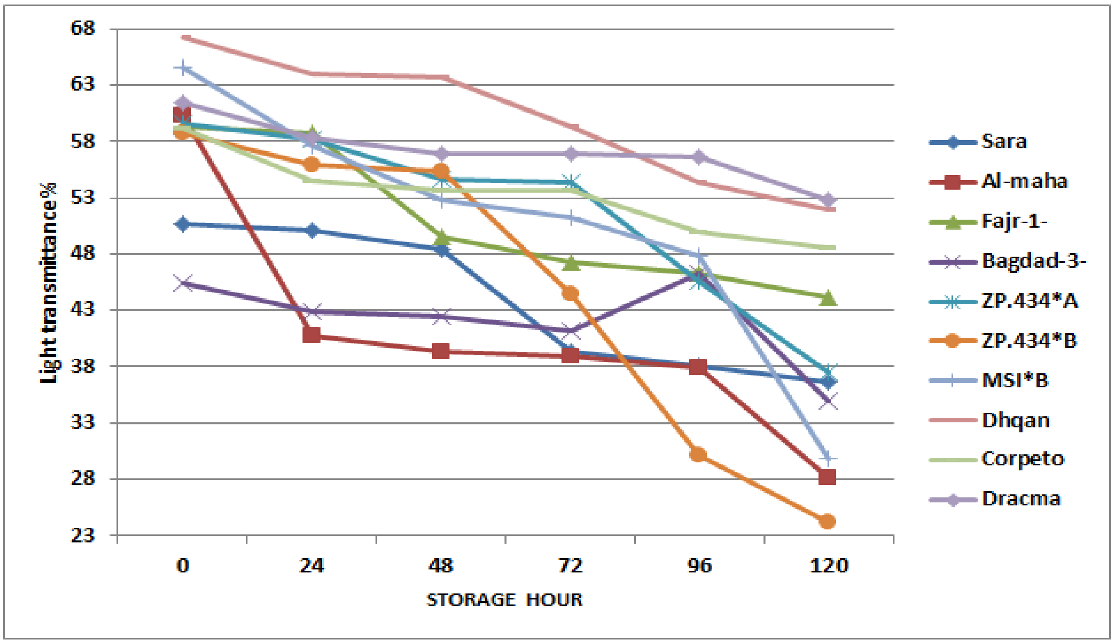

Figure (2). Effect of storage duration on light transmittance % for the corn starch genotypes

Starch pasting properties

This test is used to know the behavior of cornstarch during cooking at controlled temperature. It is one of the most important rheological parameters that determined by amylograph. Pasting properties may be affected by different factors but the nature of starch granules is the most factor. Surely, the difference in their composition and structure is corelate with genetic characteristic therefore, naturally it will occur significant differences between the tested samples of cornstarch. Previous literatures have also reported that there were variations in the corn genotypes' in pasting properties (Ketthaisong *et al*., 2013). As can be observed, there were significant differences between all parameters of pasting behavior as shown in table (3). Paste temperature is significantly varied among all studied samples which ranged from 73 to 85˚C, the highest pasting temperature was found in Dhqan and Dracma genotypes which were 84 and 85 °C, respectively, while Corpeto genotype had the lowest value (73˚C). The beginning of starch granules to gelatinize is called paste temperature which is an indicator for the temperature that the viscosity of starch suspension will increase. (Ikegwu *et al*., 2009). The second parameter peak viscosity showed that the values ranged between 400 for MSI*B to 584.667 AU for Dracma. High peak viscosity which observed by Dracma genotype indicates that it may be suitable for products requiring high gel strength and thick paste (Amoo *et al*., 2014). Peak time was significantly varied among corn starch genotypes and ranged from 52.5 for Dhqan to 43 min for ZP.434*B. The peak time and pasting temperature in both Dhqan and MSI*B were similar. These two genotypes required a longer time to reach their maximum viscosity compared to the others. For the rest of the genotypes, they exhibited moderate peak time and pasting temperature, leading to the attainment of maximum viscosity. For heat stability and Break down viscosity, both of them are recorded values only for the cornstarch's of synthetic variety which got from General Commission for Iraqi Agricultural Research -Field Crops Research Section, and the rest of genotypes didn't record any values, this may be due to differences in the genetic patterns of the species or the environment. Based on the data presented in Table 3, the peak viscosity during cooling, also known as cool paste viscosity (CPV), varied significantly among different corn genotype starches, ranging from 840 to 1220 AU. Dhqan displayed the highest CPV value at 1220 AU, while MSI*B had the lowest at 840 AU. When the paste was cooled to 50°C, viscosity generally increased. The final viscosity, referred to as cold paste viscosity (CPV), was formed at the conclusion of the cooling process at 50°C. This particular viscosity characteristic signifies a distinct quality of starch and also indicates the stability of

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cooked starch paste during practical usage. Furthermore, it reflects the starch's capacity to form a paste or gel after undergoing the cooling process (Shimelis *et al*., 2006). Cold paste viscosity is particularly important for extruded starches destined for use as ingredients in foods that require the ability to thicken at cold temperatures, such as instant creams or sauces (Alves *et al*., 1999).

Table (3). Pasting properties of starch from ten corn genotypes.

Genotypes	Past Temp.˚C	Peak Viscosity AU	Peak Time	Heat stability (trough viscosity) AU	Break down viscosity AU	Peak viscosity at cooling 50 C° AU	Setback viscosity AU
Sara	78.000 ±1.000[c]	483.000 ±1.000[f]	44.500 ±0.100[d]	441.000 ±1.000[c]	43.000 ±1.000[b]	1130.000 ±1.000[e]	700.000 ±1.000[c]
Al Maha	77.500 ±0.100[cd]	555.000 ±1.000[c]	45.500 ±0.100[cd]	521.000 ±1.000[a]	40.000 ±1.000[c]	1130.000 ±1.000[e]	605.000 ±1.000[e]
Fajr-1	77.000 ±1.000[cd]	541.000 ±1.000[d]	46.000 ±1.000[c]	515.000 ±1.000[b]	25.000 ±1.000[d]	1010.000 ±1.000[f]	500.000 ±1.000[h]
Bagdad-3	80.000 ±1.000[b]	468.000 ±1.000[g]	45.500 ±0.100[cd]	425.000 ±1.000[d]	45.000 ±1.000[a]	1145.000 ±1.000[d]	735.000 ±1.000[a]
ZP.434*A	77.500 ±0.100[cd]	463.000 ±1.000[h]	48.000 ±1.000[b]	0.000	0.000	1180.000 ±1.000[b]	705.000 ±1.000[b]
ZP.434*B	76.533 ±0.058[d]	468.000 ±1.000[g]	43.000 ±1.000[e]	0.000	0.000	1175.000 ±1.000[c]	635.000 ±1.000[d]
MSI*B	79.500 ±0.100[b]	400.000 ±1.000[i]	47.500 ±0.100[b]	0.000	0.000	840.000 ±1.000[i]	560.000 ±1.000[g]
Dhqan	84.000 ±1.000[a]	535.000 ±1.000[e]	52.500 ±0.100[a]	0.000	0.000	1220.000 ±1.000[a]	600.000 ±1.000[f]
Corpeto	73.000 ±1.000[e]	561.000 ±1.000[b]	48.500 ±0.100[b]	0.000	0.000	990.000 ±1.000[g]	405.000 ±1.000[i]
Dracma	85.000 ±1.000[a]	584.667 ±0.577[a]	46.000 ±1.000[c]	0.000	0.000	985.000 ±1.000[h]	375.000 ±1.000[j]

According to the findings presented in Table 3, setback viscosity of the various corn starches ranged from 375 to 735 AU, showing significant variability ($p < 0.05$) among the different genotypes. Bagdad-3 displayed the highest setback viscosity value, whereas Dracma had the lowest. Lower setback viscosity values hold value for food products like weaning foods, where lower viscosity and paste stability at lower temperatures are desired (Oduro *et al*., 2001).

IV. Conclusions

The corn starch from different genotypes showed variation in their characteristics which studied, such as granules size distributions, pH determination, bulk density and total phosphate content (%), Syneresis, Light transmittance and pasting properties**.** There was difference in the distribution ratios of the studied starch granules, which has considerable role for control of most physical properties of studied starch characteristics. For pH values, despite of their tendency to acidity, but it was closely to the standard as studied in previse research, for Syneresis and turbidity, there was a direct relationship between the Syneresis mean values and the duration of storage, in contrast to turbidity, which was an inverse relationship between the mean values and the duration of storage this is common in cornstarch. Paste elements, almost satisfactory results recorded. These parameters as well as other functional properties would provide relevant information for useful applications of the starches in food industries. Results of this research depend on the working conditions in our laboratories and the varieties, as well as on the production conditions for these genotypes.

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