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# Response of 3-way crosses hybrids of Corn (*Zea mays L.*) to Different fertilizer levels and its effect on growth, yield, Physicochemical and technological characteristics.

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## ABSTRACT

An experiment was conducted at Gemmeiza Research Station, Field Crops Res. Inst, Agric. Res. Center, Egypt in successive seasons (2015 and 2016) to study the response of maize four 3-way crosses (TWC 324, TWC 329, TWC 353 and TWC 354) to different Nitrogen (N) rates on growth, grain yield and technological properties of maize Four 3- way crosses white hybrids (TWC 324 and TWC 329) and yellow hybrids (TWC 353 and TWC 354) were planted under three N rates (120, 135 and 150 kg N Fed-1). Split-plot design with four replications was used. The main plots were devoted to the previous the nitrogen rates, whereas, the sub -plot were allocated to four maize hybrids. The results revealed that the effect of nitrogen rate application on 50 % tasseling and 50 % silking as well as plant and ear hight was significant in the second season. The period from planting to 50 % tasseling and 50 % silking decreased significantly by increasing the nitrogen rates up to 150 Kg N/fed in the second season. Three ways cross 353 was the earliest hybrid for number of days to 50% tasseling (58.3 days) and silking (59.3 days) in the first season, respectively. But TWC 354 was the earliest hybrid for number of days to 50% tasseling (59.8 days) and silking (60.8 days) in the second season, respectively. Three ways cross 324 and 329 showed the tallest plant height and ear height, in both seasons**.** The highest grain yield was obtained by TWC 324 (30.47 and 32.12 ard $fed^{-1}$) and TWC 329 (28.15 and 26.94 ard $fed^{-1}$) in both seasons, respectively. In contrast, Interaction effects of nitrogen rates and maize hybrids on grain yield were significant. TWC 324 significantly surpassed all hybrids (32.71 and 33.47 ard/fed) in both seasons, respectively. The grain components parts i.e. endosperm, germ and pericarp, resulted in the variation due to the hybrid and N fertilizer level which was in the line with 1000 kernel weight, and grain density during the two seasons. Protein content increase as N level increase. Meanwhile significantly increase in L* and b* values color and total carotenoids as a results of N levels and hybrids and also the NPK content in the kernels. The product tortilla prepared from white corn hybrids (TWC 324 and TWC 329) were characterized with higher score of organoleptic evaluation than those of yellow corn hybrids (TWC 353 and TWC 354). It could be recommended to produce tortilla for celiac disease adults, where it provides a part of their daily requirements of protein, carbohydrate, calcium, iron and zinc.

***Keywords:*** Corn, hybrids, N fertilizer, yield, quality characteristics, tortilla**.**

## INTRODUCTION

Corn is considered as one of the principle crops in Egypt and its production is increasing steadily; however, the majority of the crop is directed for food, animal feed and forage, in spite of the shortage in the cereal-based foodstuffs. Therefore, it would be beneficial to introduce new manufactured corn products to the Egyptian food market such as tortillas**. (El-Shayeb et al,. 2018).**

Egypt annually produces about 8.00 million tons of corn **(FAO, 2016).** While World production of maize is around 790 million tones and it serves as a staple food providing more than one-third of the calories and proteins in some countries. Also, corn enters in manufacturing some important products such as corn oil, fructose and starch. **(Chulze., 2010).** Maize is predicted to become the crop with the greatest production globally in the developing world by 2025 **(Rosegrant et al., 2008).**

Nitrogen is the most limiting nutrient for agricultural production worldwide and application of N fertilizer is generally required for optimum yield of most non-legume crops. However, sustainable agriculture must be developed to ensure long-term food security and environmental quality. Efficient N management based on application rates matched to crop demand is a critical step to produce high grain yields while avoiding environmental degradation **(Qiu et al., 2015)**.

There are several approaches to increase crop productivity, improving farming practices, employing merging technology, using modern and high yielding maize hybrids which have more efficiently for using nitrogen and more response to high rate of nitrogenous fertilizer to create more grain. Also

maize hybrids have significant effect for all the variables studied. **Kandil (2013).** Nitrogen has a major effect on growth among the major nutrients needed by plants (especially the three elements of N, P and K) **(Kagbe, & Aderian, 2003)** and Plants give it different responses. Maize need to nitrogen is differed due to weather conditions, soil type and maize rotation **(Kandil (2013).** Tortilla is an excellent mean for increasing the nutritional for special cases. Previous attempts have been made to obtain gluten–free bread of high nutritive values and acceptable quality for bread organoleptic characteristics.

Developments of gluten free products were attempted by many researchers and it was found that, gluten is essential component for dough development in case of preparation of bakery products. Preparation of gluten free bakery products is considered as major challenge to researchers. Some consumers are gluten sensitive, researchers developed gluten free tortilla from corn flour **(Mishra et al., 2015 and Sarabhai et al., 2015).** So, it is best suitable choice to fulfill the nutritional requirement of consumers. Celiac disease (CD) is also known as gluten sensitive enteropathy is an autoimmune disorder, caused due to consumption of protein called gluten, found mainly in wheat, barley and rye. It affects to 1-2% of the world population **(Reilly and Green 2012)** Consumption of gluten in diet of celiac patients leads to damage of villous atrophy of small intestine which causes severe stomach pain, bloating diarrhea, weight loss. Micronutrient deficiency observed in these patients due to failure of absorption by small intestine **(Green and Cellier 2007).**

The aim of this study was to investigate evaluate the response of modern maize hybrids of different N fertilizer levels on corn growth yield, components, and some physicochemical characteristics of grains. Application trials of the resulted corn flour in the tortilla formulation were also extended.

## MATERIALS AND METHODS:

### 1. Field experiments:

A field experiments were carried out at Gemmeiza Res. Stn. Gharbia governorate Egypt in 2015 and 2016 seasons to study maize 3-way crosses( TWC 324, TWC329, TWC353 and TWC354) the effect of high nitrogen rates (120, 135 and 150 KgN fed-1) on growth , grain yield and technological properties. Soil samples were taken before planting and chemical as well as physical analyses were done as shown in Tables (1 and 2). A side dress application of 30 kg $P_2 O_5$ and 24 kg $K_2O$ $fed^{-1}$ were applied for all plots. Plot size was two rows, 70 cm in width, 6 m in length and 25 cm between hills. Two to three kernels of hybrid were planted per hill and then thinned to one plant/hill at thinning time (one month after planting). Nitrogen fertilizer (120 Kg fed -1) was applied in the form of ammonium nitrate (33.5%) and split into two equal doses, where the first was applied during the first irrigation and the second was added after the second irrigation. Soil samples were collected before planting and analyzed for some physical and chemical properties (table 1). The Experimental design was split – plot with four replication. Nitrogen fertilizer was randomly assigned to the main plots, while hybrids were assigned in the sub plots. The recorded data were:

1- Number of days from planting to 50% tasseling.
2- Number of days from planting to 50% silking.
3- Plant height (cm) measured from ground surface to the base of tassel node.
4- Ear height (cm) measured from ground surface to the node of the topmost ear.
5- Grain yield (ard/ fad) adjusted to 15.5 % grain moisture.

Ears were harvested at maturity from the two center rows of each plot. Ears were weighed and about 5 Kg/plot were taken for moisture percent. Grain yield was adjusted to 15.5% moisture.

Statistical analysis including combining analysis over 2015 and 2016 seasons was done according to **Steel and Torrie (1980).**

**Table 1: Physical and chemical properties of the experimental soil in 2015and 2016 seasons.**

| Season | 2015 | 2016 |
|---|---|---|
| **Soil particles** | | |
| Coarse sand % | 2.80 | 2.70 |
| Fin sand % | 23.21 | 22.11 |
| Silt % | 22.94 | 23.19 |
| Clay % | 52.15 | 52.00 |
| Texture | Clay | Clay |
| **Chemical analysis** | | |
| Available N ppm | 130.5 | 125.5 |
| Available P ppm | 11.6 | 12.7 |
| Available K ppm | 290.3 | 291.5 |
| PH | 8.0 | 7.8 |
| EC (m mohs/cm) | 0.93 | 1.05 |
| D.M % | 1.53 | 1.52 |
| $CaCO_3$ % | 1.83 | 1.80 |

**2. Physicochemical characteristics of corn and tortillas:**

**Materials:**

Butanol and Iodine were purchased from Sigma-Aldrich Chemical Co., St. Louis, USA. All other used chemicals were analytical grade.

**Physical analysis**

**1000-grain weight, density and component parts of corn grains:**

The weight of 1000-grain, density and component parts (endosperm, germ and pericarp) percentages of corn grains were determined according to **Hussein (1981).**

**Color measurement of corn hybrid grains and tortillas:**

The color of corn hybrid grain and tortilla samples was measured by a hand-held Tristimulus reflectance colorimeter Minolta Chromameter (model CR-400, Konica Minolta, Japan). Results recorded in lightness with $L^*$ = 100 for lightness, and $L^*$ = zero for darkness), $a^*$ [chromaticity on a green (-) to red (+)] and $b^*$ [chromaticity on a blue (-) to yellow (+)].Values reported are the means of triplicate determinations**.** Three measurements points for three fresh tortillas samples of each type were performed **Hernández-Martínez et al (2016)**.

**Water absorption index of flour tortilla:**

Water absorption (WAI) index of flour tortillas were evaluated according to the method described by **Serena-Saldivar (2012).** All measurements were performed in triplicate.

**Corn flour preparation:**

Corn grains were carefully inspected from broken grains and extraneous matters and milled using laboratory mill (IKA-Laboratechnic, Janke and Kunkel Type: MFC, Germany) to get whole meal for chemical analysis. 60 mesh sieves was used to get fine flour for tortilla preparation and then packed in polyethylene bags and kept in a freezer -10℃ until further analysis.

**Gluten-free tortilla preparation**:

White and yellow corn grains were milled to give flour with180 micron by using an attenzione Mill, type Hz 50, 220 volts Italy. Corn tortillas were produced using the method described by **Rendon-Villalobos et al. (2009).** Corn flour was treated hydrothermally to reach the optimum ratio of added water (70, 80 and 90%). For preparation tortilla dough, the optimum condition was found to be 85% adding water and 10 min heating time. The dough of each treatment divided into 50 g pieces. Then every pieces of dough shaped, into roller shape (2 mm thick and 15 diameter) and baked in electric oven at 250°C for 5 min. Then air cooled, packed in polyethylene bags.

**Proximate analysis:**

Moisture, protein, fat, crude fibers and ash were determined according to the method of AOAC (2016). Amylose content (as g/100g dry weight) was determined using the method outlined by Juliano (1971). While carbohydrate value was calculated by difference according to **(A.O.A.C. 2016)**. Nitrogen, phosphorus, potassium, Ca, Fe and Zn contents of corn and tortilla samples were measured according

to the **AOAC (2016).** Carotenoids content was determined using the method described in **AOAC (2016).**

**Organoleptic evaluation:**

Tortilla was organoleptically evaluated according to **Salem et al. (1999)** for general appearance, roundness, odor, taste and color by (20,20, 20,20 and 20) degree, respectively with total score of 100 by a trained taste panel (n/10) of Food Technology Research Institute, Agricultural Research Centre, Giza, Egypt.

**Statistical Analysis:**

The obtained data were statistically analyzed according to **IBM Corp. Released 2011**.

## RESULTS AND DISCUSSION

**Effect of N application levels on growth characteristics, yield components and grain yield:**

**1. Growth studies**

**Nitrogen effect:**

Results in Table (2) indicated the effect of nitrogen rate application on 50 % tasseling and 50 % silking and plant and ear hight were not significant in the first season, but this effect was significant in the second season. The period from planting to 50 % tasseling and 50 % silking decreased significantly by increasing the nitrogen rates up to 150 Kg N/fed in the second season. This result is a clear illustration for the role of N in building sexual organs of maize plant. It is evident that nitrogen fertilizer encouraged the meristematic activity and increased vegetative growth which pushed maize plants towards earlier tasseling and silking. Similar results were obtained by **Nofal, Fatma (1994), El- Mekser, Hoda and Seiam, Mofeeda (2008).**

Data presented in the same table showed clearly that plant height was increased significantly by increasing the nitrogen levels from 120, 135 and 150 Kg N/fed. The tallest plants placement resulted from applying 150 Kg N/fed compared to 120 Kg N/ fed in the second season. Results revealed that the highest grain yield was obtained when 150 Kg N/fed was applied compared to 120 Kg N/fed in both seasons. Whereas, these results indicate clearly that nitrogen is necessary for protoplasm formation, photosynthesis activity, cell division and meristematic activity in plant organs.

**Table (2): Effect of nitrogen (N) levels on days to 50% tasseling (DTT), days to 50% silking (DTS), plant height (PHT), ear height (EHT), and grain yield ard fed-1), in 2015/ 2016 seasons.**

| 2015 | | | | | |
|---|---|---|---|---|---|
| **Treatment N (Kgfed-1)** | **Tass** | **Silk** | **Pht** | **Eht** | **Yield** |
| 120 | 58.8 | 59.8 | 241 | 139 | 25.18 |
| 135 | 58.6 | 59.6 | 245 | 142 | 27.28 |
| 150 | 58.6 | 59.6 | 246 | 139 | 28.43 |
| L.S.D | Ns | Ns | Ns | Ns | 1.92 |
| C.V | 0.81 | 0.82 | 3.77 | 6.37 | 7.44 |
| **2016** | | | | | |
| 120 | 62.3 | 63.0 | 262 | 150 | 25.12 |
| 135 | 60.4 | 61.3 | 269 | 153 | 26.33 |
| 150 | 60.1 | 61.1 | 270 | 153 | 28.22 |
| L.S.D | 0.71 | 0.90 | 5.78 | Ns | 1.37 |
| C.V | 1.62 | 1.65 | 3.69 | 5.71 | 6.14 |

**Hybrid effect:**

Data in Table (3) show that significant differences between hybrids for number of days to 50% tasseling and silking in both growing seasons were detected. Three way cross 353 was the earliest hybrid for number of days to 50% tasseling (58.3 days) and silking (59.3 days) in the first season, respectively. But TWC 354 was the earliest hybrid for number of days to 50% tasseling (59.8 days) and silking (60.8 days) in the second season,

respectively. Meanwhile, three ways cross 329 recorded the latest hybrid for tasseling (58.9 and 61.8 days) and silking (59.9 and 62.6 days) in the two seasons, respectively. The observed significant variation among hybrids might reflect partially their different genetic backgrounds. Three way cross 324 and Three way cross 329 showed the tallest plant height and ear height, but TWC 353 was the shortest hybrid in both seasons.

There were significant differences among hybrids in grain yield in the first and the second seasons. The highest grain yield was obtained by TWC 324 (30.47 and 32.12 ard $fed^{-1}$) and TWC 329 (28.15 and 26.94 ard $fed^{-1}$) in both seasons, respectively. In contrast, TWC 353 and 354 had the lowest grain yield (24.87 and 24.38 ard $fed^{-1}$), in the first season and (20.66 and 26.51 ard $fed^{-1}$) in the second season, respectively (Table 3).

**The interaction between nitrogen level and hybrids:**

Interaction effects of nitrogen rates and maize hybrids on grain yield were significant as shown in (Table 4). Concerning 150 Kg N/fed, TWC 324 significantly surpassed all hybrids (32.71 and 33.47 ard/fed) in both seasons, respectively. While the lowest grain yield (17.56 ard $fed^{-1}$) was linked to applying 120 kg N $fed^{-1}$ with TWC353 in the second season.

**Table (3): Effect of hybrids on days to 50% tasseling (DTT), days to 50% silking (DTS), plant height (PHT), ear height (EHT), and grain yield ( ard fed -1), in 2015 / 2016 seasons.**

| **2015** | | | | | |
|---|---|---|---|---|---|
| **Treatment Hybrids** | **Tass** | **Silk** | **Pht** | **Eht** | **yield** |
| TWC 324 | 59.0 | 59.9 | 257 | 149 | 30.47 |
| TWC 329 | 58.9 | 59.9 | 252 | 143 | 28.15 |
| TWC 353 | 58.3 | 59.3 | 232 | 133 | 24.87 |
| TWC 354 | 58.5 | 59.5 | 235 | 135 | 24.38 |
| L.S.D | 0.40 | 0.41 | 7.72 | 7.46 | 1.68 |
| C.V | 0.81 | 0.82 | 3.77 | 6.37 | 7.44 |
| **2016** | | | | | |
| TWC 324 | 61.0 | 61.9 | 285 | 159 | 32.12 |
| TWC 329 | 61.8 | 62.6 | 296 | 172 | 26.94 |
| TWC 353 | 61.1 | 61.9 | 240 | 135 | 20.66 |
| TWC 354 | 59.8 | 60.8 | 247 | 143 | 26.51 |
| L.S.D | 0.83 | 0.85 | 8.25 | 7.29 | 1.37 |
| C.V | 1.62 | 1.65 | 3.69 | 5.71 | 6.14 |

$TWC_{324}$ and $TWC_{329:}$ white corn hybrids - $TWC_{353}$ and $TWC_{354:}$ yellow corn hybrids.

**Table (4): Effect of interaction between nitrogen (N) rates and hybrids on grain yield (ard fed-1) in 2015 and 2016 seasons.**

| **Yield** | | | | | | |
|---|---|---|---|---|---|---|
| **N** | **120** | | **135** | | **150** | |
| Hyb | 2015 | 2016 | 2015 | 2016 | 2015 | 2016 |
| Twc324 | 26.39 | 31.08 | 32.33 | 31.80 | 32.71 | 33.47 |
| Twc329 | 26.12 | 27.43 | 28.38 | 25.22 | 29.93 | 28.18 |
| Twc353 | 24.13 | 17.56 | 22.89 | 21.09 | 24.94 | 23.33 |
| Twc354 | 24.08 | 24.41 | 25.53 | 27.22 | 26.16 | 27.92 |
| L.S.D | 0.51 | 0.72 | 0.83 | 0.80 | 0.53 | 0.51 |
| C.V | 7.44 | 6.14 | 7.44 | 6.14 | 7.44 | 6.14 |

$TWC_{324}$ and $TWC_{329:}$ white corn hybrids - $TWC_{353}$ and $TWC_{354:}$ yellow corn hybrids.

**1000-grains weight, density and component parts of corn grains:**

1000-grains weight, density and component parts (endosperm, germ and pericarp) of hybrids corn grains after using different fertilizer levels at seasons 2015 and 2016 are presented in Table (5). Data showed that the highest 1000-grains weight, under 135 and 150 kg N / Fed being,375.67 and 400 mg

respectively for TWC 324 in 2015 season Meanwhile in 2016 season a decrease was found or increases under the all treatment of N fertilizes. TWC 324 under 135 N kg / Fed level was highest being 345.5 g and TWC 329 was highest value under 150 N kg / Fed being 354.5 g. These results are higher than those of **(Mohamed and Abdel Aal 2005& Abd El-Lateef and Bughdady2018)** who reported that1000-grains weight, of white corn hybrids ranged from 298.0 to 398.70 and 275.53 to 353.33 g for white corn and yellow corn hybrids ranged from 276.5 to 373.2 and higher than those of **(EL-Mekser et al. 2016)** who mentioned that that1000-grains weight, of yellow corn ranged from 275.5 to 290.5 g.

Density showed that the highest value for TWC 324, in 2015 season under 120 and 135 kg N / Fed being 1.47 and 1.56 g/cm$^3$ respectively. Endosperm showed its maximum value for TWC 324, in 2015 season being 82.19, 81.55 and 80.79 % under 120, 135 and 150 kg N / Fed respectively. Meanwhile it was 83.03 and 83. 70 and 82.76 of TWC 324, TWC329 and TWC 354 in 2016 season under the above entioned treatments, respectively. Germ and pericarp showed its maximum content of TWC329 and TWC354 hybrids recorded the highest value of germ 12.95,12.41 and 11.49 % in season 2015 and pericarp TWC353 respectively in both seasons. This result are in agreement with those obtained by **(Mohamed and Abdel Aal 2005)** who reported that the hull % ranged from 6.11 to 11.39 for white maize hybrids and ranged from 5.43 to 9.74 for yellow maize hybrids.

**Proximate chemical composition of corn:**

The chemical composition of corn kernel meal resulted in highest protein content under 135 and 150 kg N / Fed it could be observed that protein content increased as a result of increasing fertilizer levels. being 9.22. 9.34 %, respectively for TWC 353 in 2015 season. Meanwhile in 2016 season a slight ncreases was found or decrease under the all treatment of fertilizer with non-significant differences. These results are in the same trend with those found by **Ibrahim and Kandil (2007)** who reported that chemical constituents are significant increase by nitrogen application.

Fat content showed its maximum value for TWC 329, TWC 353, TWC 329 and TWC 353 in both seasons under 120, 135 and 150 kg N / Fed respectively which was significant increase than those of other treatment and seasons respectively. Total carbohydrates showed its maximum value for TWC 324, TWC 354, TWC 324 in 2015 season being 85.46, 84.07 and 84.82 % under 120, 135 and 150 kg N / Fed respectively. Meanwhile it was 85.79, 84.67 and 84.52 of TWC 324 TWC 324 and TWC 329 in 2016 season under the abovementioned treatments, respectively. Amylose content showed its maximum content of 29.72, 28.82 and 27.41 for TWC 354, TWC 353 and TWC 324 under 120, 135 and 150 kg / Fed N, respectively in 2015 season. The maximum amylose content was found to be 29.18, 28.94 and 28.42 % under the same fertilize level of TWC 354, TWC 353 and TWC 324 in 2016 season. Ash and fiber showed slight increase or decrease due to N fertilizer levels or the hybrid. From the above mentioned data it could be conclude that many factors played a role in the chemical composition such as fertilizer, hybrid, weather, soil chemical and physical structure and also the irrigated water.

**N, P and K contents of corn grain treated with different levels of N during 2015 and 2016 seasons:**

The effect of nitrogen rates on some corn grain minerals content are shown in table 7. N. P and K content of corn hybrid grain showed that N content ranged from 1.13 - 1.47% and 0.8 to 2.6% in 2015 and 2016 growing season respectively. The highest N value was found in TWC 324 followed by TWC 354 which amounted in 1.47 and 1.44%, respectively in 2015 season under 120 Kg N/Fed while the lowest value was found in TWC 329 and TWC 324 under 120 and 135 kg N/Fed being 1.13 and 1.19% respectively. In 2016 season an increase in N content under 120 Kg N/Fed for all hybrids which ranged between 1.4 – 1.8%. Also, the same hybrids resulted increase in N content under N application with 150 Kg N/Fed except that of TWC 354 which showed similar result as that of 2015 (1.26 as 1.26). The other hybrids showed a range of 1.15 to 2.6%. Treatment with 135 Kg /Fed resulted in similar as that of 2015 except that of TWC 354 which showed a decrease by about 64% compared with 2015 season. P content ranged from 0.108 to 0.172%, 0.091 – 0.22% and 0.07 – 0.16% under 120, 135 and 150 Kg N/Fed for all hybrids respectively in 2015 season. In 2016 season, the range was 0.095 – 0.775%, 0.084 – 0.112% and 0.108 – 0.134%, for the above-mentioned treatments and hybrids. It worth mentioning that the application with 150 Kg N/Fed increased P content compared with 2016

season. Concerning K content, it ranged from 0.13 – 0.14%, 0.13 – 0.15% and 0.13 -0. 14% under 120, 135 and 150 Kg N/Fed for all hybrids study in 2015 season. It showed almost that same P content in 2016 season. From the aforementioned data, it could be concluded that N fertilizer affected its content in grain and also P and K. The obtained data were in the line with those of **Mohamed and Abdel-Aal (2005)** & **Abd EI-Lateef and Bughdady (2018)** found that N% of some white corn hybrids under different level fertilizer was 1.516 to 1.819% and 1.460 to 1.833% for seasons 2014 and 2015. P% was ranged from0.203 to 0.260 and ranged from 0.201 to 0.273 % K% was ranged from 0.332 to 0.377% and between 0.333-0.381 % for both seasons 2014 and 2015.

**Color characteristics and total carotenoid of corn grains hybrid**:

The data in table (8) revealed that in 2015 season, *(L*)* value showed on range of 73.57-79.67, 63.61- 88.85 and 72.02- 83.61under 120, 135 and 150 kg N/Fed for the studied hybrid, respectively. Meanwhile it amounted in a range of 67.07-72.64, 67.47- 81.71 and 74.62- 79.21 in 2016 season. *( a*)* showed it range of 0. 45-8.10, 0.003- 6.25 and 0.08-5.02 in 2015 season and valued in 0.42- 7.49, 0.65- 6.64 and 0.47- 6.73 in 2016 season. *(b*)* found to be in a range of 28.77- 49.68, 24.61- 41. 34 and 25.36- 44.97 in 2015 season of the studied treatments and hybrids and valued in 21.19-48.96,24.57-46.99 and 25.94-46.89 in season 2016. From the above mention data, it be conclude that N fertilize resulted in non or slight effect on *(L*)* values while same hybrid showed a great effect on its values of *( a*)* and *(b*)*. Concerning total carotenoid (mg/kg$^{-1}$) the white hybrid (TWC 324 and TWC 329) amounted in 4.63 and 5.24, 4.55 and 4.11 & 3.74 and 3.77 in 2015 season while its amount was 4.71 and 5.26, 4.48 and 4.42 & 3.79 and 3.79 respectively in 2016 under fertilizer 120, 135 and 150 kg N /Fed. On the other hand, yellow hybrid (TWC 353, TWC 354) contained 11.55 and 13.97, 12.86 and 12.45 & 12.36 and 11.33 in 2015 season while it was 11.76 and 13.19, 12.71 and 12.74 & 12.41 and 11.39. From the obtained results, it could be concluded that the produced hybrids showed a slight effect in the color and total carotenoids due to N fertilizes levels. The obtained results agree with **Mohamed and Abdel-Aal (2005)** who reported that the yellow maize hybrid had higher amounts than the white corn hybrids recorded a range of 8.76 to 17.25 and 4.45 to 7.06.

**Sensory Evaluation of tortilla**

Organoleptic evaluation of tortilla is very appropriate for celiac disease. It has no gluten in its protein and has easily digested carbohydrates (**Gujral et al 2003**)**.** Organoleptic evaluation of different tortillas prepared from white and yellow corn hybrids cultivated in 2016 season is shown in Table (9). Data indicated that, general appearance decreased significantly in tortillas made from yellow corn hybrids with the increasing of the fertilizer level up to 120 kg fed$^{-1}$. It ranged between 16.70 and 17.80 while tortillas made from white corn hybrids general appearance had higher values, it ranged between 18.10 and 19.20. In addition, there were non-significant differences in odor character between all tortilla samples. The highest values were in white corn hybrids TWC324 and TWC329 which recorded (19.40 and 19.20) respectively at 120 kg N fed$^{-1}$. Moreover, the highest values for tortilla made from yellow corn hybrids were TWC353 and TWC354 were observed. Concerning color character, there were significant differences between samples. The highest score was observed for tortilla made from hybrids TWC 234 (19.40) at N level 120 kg fed$^{-1}$. While the lowest value was observed in tortilla made from hybrid TWC353 which recorded (16.40) at N level 135 kg fed$^{-1}$. **EL-Mekser et al (2014)** indicated that general appearance of tortillas made from yellow corn it ranged between 16.62 to 18.62. From the above-mentioned results, it could be concluded that the tortillas prepared from the white corn hybrids (TWC324 and TWC329) were characterized with higher score of organoleptic evaluation than those of yellow hybrids (TWC353 and TWC354).

**Physical and color characteristics of tortilla samples:**

Physical characteristic (WAI) values of flour tortilla prepared from corn hybrids at different nitrogen fertilizer levels are demonstrated in Table (10). From the results, it could be noticed that value of WAI of flour tortilla being 4.19, 4.30 and 4.59 for TWC354 which recorded the highest values at all N fertilizer levels. Water absorption index (WAI) value is in agreement with those obtained by **Iuga et al (2019)** for flour tortillas from different maize which ranged from 3.80 to 4.46 and 2.07 to 5.14.

**Table (5): 1000-grains weight, density and grain component parts of corn at season 2015 and 2016 under different fertilizer levels and nitrogen application times**

| Treatments N (kg Fed-1) | Crosses | 1000 grains weight(g) | Density (g/cm3) | Endosperm (%) | Germ (%) | Pericarp (%) | 1000 grains weight(g) | Density (g/cm3) | Endosperm (%) | Germ (%) | Pericarp (%) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2015 | | | | | 2016 | | | | |
| 120 | TWC 324 | 355.0±9.00d | 1.47±0.26ab | 82.2±1.7a | 10.8±1.9bcd | 7.0±0.2cd | 333.0±8.0a | 1.2±0.3cd | 83.0±0.0ab | 9.9±0.2b | 7.1±0.3ef |
| | TWC 329 | 321.7±12.50e | 1.07±0.04c | 78.1±1.1b | 13.0±1.04a | 9.2±0.6a | 334.5±19.5a | 1.1±0.1cd | 81.0±1.1abcd | 10.7±0.2b | 7.4±0.0def |
| | TWC 353 | 266.0±16.0f | 1.12±0.13bc | 81.8±4.9a | 9.6±1.84 | 9.9±1.5a | 276.0±12.0b | 1.1±0.0d | 78.1±2.0d | 13.8±1.4a | 8.1±0.6bcd |
| | TWC 354 | 307.0±7.0e | 1.25±0.00ab c | 80.5±0.0ab | 12.8±0.4a | 6.8±0.4d | 297.0±16.0 b | 1.1±0.0d | 81.2±0.6abcd | 12.0±0.2 ab | 6.8±0.3fg |
| 135 | TWC 324 | 375.7±7.5cd | 1.56±0.28a | 81.6±0.7a | 11.7±0.2abc | 6.8±0.6d | 345.5±8.5a | 1.2±0.2cd | 79.6±1.5cd | 12.2±1.0ab | 7.7±0.5cde |
| | TWC 329 | 367.7±5.5d | 1.23±0.02abc | 79.4±0.4ab | 12.0±0.7abc | 8.6±0.3ab | 334.0±2.0a | 1.2±0.0cd | 83.7±0.1a | 9.9±0.3b | 6.4±0.4g |
| | TWC 353 | 291.7±24.5ef | 1.01±0.01c | 79.9±0.1ab | 12.4±0.4ab | 7.7±0.5bcd | 283.5±5.3ab | 1.4±0.4a | 80.7±1.0abcd | 11.0±0.9b | 8.2±0.9bc |
| | TWC 354 | 319.7±1.5e | 1.05±0.00c | 80.6±1.0ab | 12.4±1.2ab | 7.0±0.2cd | 325.0±4.0a | 1. 2±0.0c | 80.7±0.6abc d | 11.6±0.5b | 7.7±0.1cde |
| 150 | TWC 324 | 400.0±8.0c | 1.01±0.01c | 80.8±0.3ab | 10.4±0.1cd | 9.1±0.63a | 348.0±8.0a | 1.1±0.1cd | 82.7±0.2abc | 10.7±0.2b | 7.3±0.1def |
| | TWC 329 | 365.0±4.0d | 1.22±0.02abc | 80.5±1.4ab | 10.8±1.1bcd | 8.7±0.2ab | 354.5±4.5a | 1.2±0.2cd | 79.9±1.9bcd | 11.5±0.9b | 8.6±0.1b |
| | TWC 353 | 303.0±2.0e | 1.19±0.15bc | 80.4±0.7ab | 10.8±0.8bcd | 9.1±1.3a | 318.0±7.0ab | 1.4±0.2ab | 79.7±1.8cd | 10.8±1.4b | 9.6±0.5a |
| | TWC 354 | 375.0±0.0 cd | 1.07±0.01c | 80.3±1.4ab | 11.5±0.8abcd | 8.2±0.6abc | 326.5±18.5ab | 1.1±0.1d | 82.8±1.9abc | 10.2±1.7b | 7.8±0.3cde |

$TWC_{324}$ and $TWC_{329:}$ white corn hybrids - $TWC_{353}$ and $TWC_{354:}$ yellow corn hybrids. Values are means of three replicates ±SD. Values number in the same raw followed by the same letter are not significantly different at 0.05 level.

**Table 6: Gross chemical compositions% of corn hybrids whole meal under different fertilizer levels at season 2015 and 2016 (on dry weight basis)**

| Treatments N (kg Fed$^{-1}$) | Crosses | Moisture (%) | Protein (%) | Fat (%) | Ash (%) | fiber (%) | Carbohydra-tes (%) | Amylose (%) |
|---|---|---|---|---|---|---|---|---|
| | **2015** | | | | | | | |
| **120** | TWC 324 | 6.1±0.11$^{b}$ | 7.58±0.05 a | 3.47±0.23bcd | 1.36±0.17bcd | 2.1±0.15cde | 85.5±0.5a | 27.4±0.03b |
| | TWC 329 | 6.0±1.00$^{ab}$ | 7.79±0.11 a | 3.94±0.51ab | 1.65±0.14a | 2.3±0.01f | 84.3±0.7ab | 26.6±0.13c |
| | TWC 353 | 7.3±0.25$^{a}$ | 8.19±0.36 a | 3.90±0.06abc | 1.51±0.14abc | 1.8±0.17a | 84.6±0.5ab | 28.2±0.70a |
| | TWC 354 | 6.5±0.01$^{a}$ | 8.41±0.23 a | 3.75±0.18abcd | 1.27±0.02d | 2.8±0.15b | 83.8±0.01b | 28.9±0.92a |
| **135** | TWC 324 | 6.5±0.02$^{ab}$ | 7.72±0.01 a | 3.43±0.43bcd | 1.53±0.10ab | 2.6±0.05b | 84.7±0.6ab | 26.5±0.17c |
| | TWC 329 | 7.0±0.02$^{a}$ | 8.79±0.00 a | 3.60±0.55abcd | 1.39±0.01bcd | 2.3±0.01cd | 83.9±0.5b | 27.1±0.55b |
| | TWC 353 | 7.0±0.04$^{a}$ | 9.22±0.22 a | 3.46±0.29bcd | 1.42±0.16e | 2.4±0.01c | 83.5±0.3b | 28.1±0.16a |
| | TWC 354 | 6.0±0.03$^{b}$ | 8.52±0.01 a | 4.16±0.41a | 1.08±0.04d | 2.2±0.04def | 84.1±0.7ab | 29.6±0.09a |
| **150** | TWC 324 | 6.0±0.02$^{b}$ | 8.44±0.10 a | 3.30±0.25cd | 1.28±0.17d | 2.2±0.06ef | 84.8±0.4ab | 27.4±0.07b |
| | TWC 329 | 7.0±0.05$^{a}$ | 8.90±0.08 a | 3.72±0.32abcd | 1.32±0.06cd | 2.2±0.03def | 83.9±0.03b | 27.2±0.19b |
| | TWC 353 | 6.5±0.05$^{ab}$ | 9.34±0.09 a | 3.62±0.08abcd | 1.31±0.01d | 2.4±0.01def | 83.3±0.04b | 28.8±0.03a |
| | TWC 354 | 6.9±0.04$^{a}$ | 8.52±0.07 a | 3.25±0.04d | 1.22±0.04de | 2.4±0.18c | 84.6±0.6ab | 29.3±0.01a |
| | **2016** | | | | | | | |
| **120** | TWC 324 | 7.1±0.02$^{a}$ | 7.0±0.85 a | 3.64±0.68cde | 1.39±0.04a | 2.2±0.07def | 85.8±0.04a | 28.4±0.99$^{a}$ |
| | TWC 329 | 7.2±0.04$^{a}$ | 7.3±0.21 a | 3.88±0.27abcd | 1.46±0.045a | 2.4±0.06abcd | 85.0±0.04ab | 26.27±0.21c |
| | TWC 353 | 7.6±0.06$^{a}$ | 8.0±0.25 a | 4.11±0.49ab | 1.29±0.09a | 2.4±0.11ab | 84.1±0.8ab | 28.94±0.43a |
| | TWC 354 | 7.8±0.53$^{a}$ | 8.9±0.39 a | 3.57±0.37e | 1.31±0.02a | 2.3±0.01abcde | 84.0±0.5b | 28.50±1.04a |
| **135** | TWC 324 | 7.0±0.48$^{a}$ | 8.2±0.35 | 3.7±0.10cde | 1.27±0.25a | 2.2±0.09cdef | 84.7±0.9ab | 27.43±0.13b |
| | TWC 329 | 6.3±0.04$^{a}$ | 7.7±1.93 a | 3.83±0.96abc | 1.35±0.05a | 2.5±0.015a | 84.7±0.7ab | 27.16±1.37b |
| | TWC 353 | 7.3±0.10$^{a}$ | 8.5±0.04 a | 4.09±0.41de | 1.23±0.03a | 2.4±0.12abcd | 83.8±0.03b | 28.36±0.14a |
| | TWC 354 | 6.9±0.01$^{a}$ | 8.9±0.04 a | 3.60±0.23cde | 1.18±0.02a | 2.4±0.17abcd | 84.0±0.5b | 28.70±0.45a |
| **150** | TWC 324 | 6.7±0.04$^{a}$ | 8.5±0.66 a | 3.45±0.13cde | 1.28±0.01 a | 2.0±0.03f | 84.7±0.5ab | 28.00±0.66a |
| | TWC 329 | 5.9±0.10$^{b}$ | 8.0±0.18 a | 3.98±0.17abcd | 1.48±0.22 a | 2.0±0.01f | 84.5±0.3ab | 27.52±1.15b |
| | TWC 353 | 6.8±0.06$^{a}$ | 8.5±0.10 a | 4.22±0.66 | 1.19±0.09 a | 2.2±0.05bcdef | 83.9±0.5 b | 28.15±1.23a |
| | TWC 354 | 6.8±0.11$^{a}$ | 8.9±0.10 a | 3.75±0.38 | 1.33±0.09 a | 2.1±0.01ef | 83.9±0.3b | 29.18±0.04a |

$TWC_{324}$ and $TWC_{329}$: white corn hybrids - $TWC_{353}$ and $TWC_{354}$: yellow corn hybrids. Values are means of three replicates ±SD. Values number in the same raw followed by the same letter are not significantly different at 0.05 level.

**Table7: N, P and K contents of corn hybrids grains in 2015 and 2016 seasons under Gemmeiza Res. Stn. conditions.**

| Treatments N (kg Fed$^{-1}$) | Crosses | N (%) | P (%) | K (%) | N (%) | P (%) | K (%) |
|---|---|---|---|---|---|---|---|
| | | **2015** | | | **2016** | | |
| **120** | TWC 324 | 1.47 | 0.117 | 0.14 | 1.6 | 0.125 | 0.128 |
| | TWC 329 | 1.13 | 0.172 | 0.14 | 1.4 | 0.095 | 0.130 |
| | TWC 353 | 1.35 | 0.108 | 0.13 | 1.8 | 0.775 | 0.128 |
| | TWC 354 | 1.44 | 0.143 | 0.14 | 1.6 | 0.122 | 0.133 |
| **135** | TWC 324 | 1.19 | 0.091 | 0.13 | 1.2 | 0.084 | 0.134 |
| | TWC 329 | 1.22 | 0.116 | 0.14 | 1.2 | 0.112 | 0.131 |
| | TWC 353 | 1.24 | 0.110 | 0.14 | 1.2 | 0.110 | 0.130 |
| | TWC 354 | 1.25 | 0.22 | 0.15 | 0.8 | 0.110 | 0.134 |
| **150** | TWC 324 | 1.36 | 0.14 | 0.14 | 2.6 | 0.108 | 0.136 |
| | TWC 329 | 1.31 | 0.07 | 0.14 | 1.6 | 0.134 | 0.132 |
| | TWC 353 | 1.38 | 0.10 | 0.13 | 1.5 | 0.108 | 0.127 |
| | TWC 354 | 1.26 | 0.16 | 0.14 | 1.26 | 0.134 | 0.133 |

$TWC_{324}$ and $TWC_{329}$: white corn hybrids - $TWC_{353}$ and $TWC_{354}$: yellow corn hybrids. Values are means of three replicates ±SD. Values number in the same raw followed by the same letter are not significantly different at 0.05 level.

**Table 8: Color characteristics and total carotenoid (mg kg$^{-1}$) content of corn grains in season 2015 and 2016 .**

| Treatments N (kg Fed$^{-1}$) | Crosses | L* | a* | b* | Total carotenoid (mg kg$^{-1}$) | L* | a* | b* | Total carotenoid (mg kg$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| | | 2015 | | | | 2016 | | | |
| 120 | TWC 324 | 76.45±1.76abc | 0.45±0.13cd | 28.82±5.45cd | 4.63±0.02 | 69.96±1.27ab | 0.64±0.120c | 21.19±2.24c | 4.71±0.06 |
| | TWC 329 | 77.11±6.12abc | 1.24±1.06bcd | 28.77±4.18cd | 5.24±0.02 | 70.75±1.93ab | 0.42±0.39c | 20.83±0.75c | 5.26±0.87 |
| | TWC 353 | 79.67±3.58abc | 8.10±1.84a | 49.68±4.23a | 11.55±0.04 | 67.07±0.40b | 3.20±0.40bc | 48.96±0.80bc | 11.76±1.02 |
| | TWC 354 | 73.57±4.94bc | 4.96±0.65abc | 34.81±8.13bc | 13.97±0.02 | 72.64±2.68ab | 7.49±3.49a | 43.93±10.93a | 13.19±0.02 |
| 135 | TWC 324 | 88.85±3.89a | 0.22±0.39d | 26.48±4.34cd | 4.55±0.05 | 67.47±0.69b | 1.09±0.21c | 24.57±1.06c | 4.48±0.03 |
| | TWC 329 | 86.63±4.24ab | 0.003±0.006d | 24.61±5.42d | 4.11±0.09 | 81.71±4.77 | 0.65±0.46c | 26.55±16.11a | 4.42±0.36 |
| | TWC 353 | 72.23±3.33c | 6.25±2.67a | 41.34±9.81ab | 12.86±0.02 | 77.29±4.20ab | 6.64±3.51a | 41.35±5.37ab | 12.71±0.37 |
| | TWC 354 | 63.61±5.56d | 5.45±1.03ab | 41.06±5.71cd | 12.45±0.25 | 74.32±2.72ab | 5.43±1.43ab | 46.99±17.67a | 12.74±0.00 |
| 150 | TWC 324 | 81.91±3.77ab | 0.70±0.30cd | 29.89±1.78cd | 3.74±0.02 | 74.62±4.63ab | 1.15±0.44c | 27.29±2.72bc | 3.79±0.04 |
| | TWC 329 | 83.61±3.89a | 0.08±0.14d | 25.36±0.82cd | 3.77±0.01 | 76.43±7.93ab | 0.47±0.15c | 25.94±3.12c | 3.79±0.13 |
| | TWC 353 | 74.51±3.33bc | 5.02±3.56abc | 42.98±1.76b | 12.36±0.02 | 77.11±5.45ab | 6.73±2.95a | 45.83±4.76a | 12.41±0.03 |
| | TWC 354 | 72.02±6.72c | 4.22±1.73abcd | 44.97±1.01cd | 11.33±0.03 | 79.21±5.82ab | 6.19±0.53ab | 46.89±5.64a | 11.39±0.86 |

$TWC_{324}$ and $TWC_{329}$: white corn hybrids - $TWC_{353}$ and $TWC_{354}$: yellow corn hybrids. Values are means of three replicates ±SD. Values number in the same raw followed by the same letter are not significantly different at 0.05 level.

**Table 9: Sensory evaluation of gluten-free tortilla prepared from corn hybrids cultivated at 2016 season.**

| Treatments N (kg Fed$^{-1}$) | Crosses | Appearance (20) | Roundness (20) | Odor (20) | Taste (20) | Color (20) | Total score (100) |
|---|---|---|---|---|---|---|---|
| 120 | TWC 324 | 19.20±1.033a | 19.50±0.707ab | 19.40±0.699a | 19.25±0.920 a | 19.40±0.699a | 96.75±3.208a |
| | TWC 329 | 19.15±0.747a | 19.40±0.966ab | 19.20±0.789 a | 18.50±1.269 ab | 19.20±1.229ab | 95.45±3.961ab |
| | TWC 353 | 17.80±1.317ab | 19.30±0.675ab | 17.70±1.889 a | 17.00±2.211 ab | 17.40±1.075bcd | 89.20±5.731abcd |
| | TWC 354 | 17.30±1.829ab | 18.80±1.549ab | 17.90±1.912 a | 17.50±1.650 ab | 17.10±1.449cd | 88.10±7.172abcd |
| 135 | TWC 324 | 18.00±1.155ab | 19.65±0.474a | 18.50±1.354 a | 18.50±1.434 ab | 18.30±1.494abcd | 92.10±6.790abcd |
| | TWC 329 | 18.70±1.252b | 19.80±0.422a | 19.10±0.994 a | 18.70±1.418 ab | 18.80±1.135abc | 95.10±4.557abc |
| | TWC 353 | 16.80±1.751ab | 18.80±1.229ab | 17.50±1.900 a | 16.80±1.687b | 16.40±1.506d | 86.30±6.129cd |
| | TWC 354 | 17.20±1.476ab | 19.30±0.675ab | 17.70±1.829 a | 17.10±1.524ab | 17.80±1.135abcd | 89.10±4.332abcd |
| 150 | TWC 324 | 18.60±1.174ab | 19.40±0.699ab | 18.70±1.252 a | 18.10±0.876 ab | 18.70±0.823abc | 93.50±2.877abcd |
| | TWC 329 | 18.10±1.101ab | 19.50±0.707ab | 18.40±1.350 a | 18.10±1.370 ab | 18.60±0.843abc | 92.70±3.974abcd |
| | TWC 353 | 16.90±1.524b | 18.00±2.582ab | 17.20±2.616 a | 16.50±2.273b | 16.90±1.853cd | 85.50±8.209d |
| | TWC 354 | 16.70±2.214b | 17.60±2.547b | 17.60±2.547 a | 17.00±2.160 ab | 17.60±1.838abcd | 86.70±10.678bcd |

$TWC_{324}$ and $TWC_{329}$: white corn hybrids - $TWC_{353}$ and $TWC_{354}$: yellow corn hybrids. Values are means of three replicates ±SD. Values number in the same raw followed by the same letter are not significantly different at 0.05 levels.

Concerning the data of tortilla crumb color, the lightness ($L^*$) value of tortilla varies due to differences between hybrids corn flour color which recorded highest value for TWC324 recorded (82.98, 80.96 and 79.27) and the lowest values were recorded (76.65,74.52 and71.96) for TWC354 at all N fertilizer levels. The yellowness ($b^*$) value of tortilla showed the highest value being 42.82, 41.50 and 44.83 for TWC353 while the lowest values were found TWC329 and TWC324 under all N fertilizer levels which ranged between 32.36-29.89, 29.35-29.68 and 30.94-35.12 respectively.

**Table (10): Water absorption index of corn hybrid flour (g/100g) and Color characteristics of tortilla samples in season 2016 under different N fertilizer levels**.

| Treatments N (kg Fed$^{-1}$) | Tortilla samples | WAI | L* | a* | b* |
|---|---|---|---|---|---|
| | **2016** | | | | |
| **120** | **TWC 324** | 4.03±0.28$^{b}$ | 82.98±1.22$^{a}$ | 0.80±0.08$^{a}$ | 32.36±1.21$^{e}$ |
| | **TWC 329** | 3.93±0.18$^{b}$ | 80.83±1.34$^{a}$b | 0.70±0.05$^{ab}$ | 29.89±1.45$^{ef}$ |
| | **TWC 353** | 4.06±0.22$^{b}$ | 76.67±1.51$^{def}$ | 0.45±0.07b$^{cd}$ | 42.82±1.98$^{ab}$ |
| | **TWC 354** | 4.19 0.36$^{ab}$ | 76.65±1.82$^{def}$ | 0.47±0.13$^{bcd}$ | 39.37±1.11$^{c}$ |
| **135** | **TWC 324** | 3.91±0.32$^{b}$ | 80.96±1.56$^{ab}$ | 0.78±0.12$^{a}$ | 29.35±1.01$^{f}$ |
| | **TWC 329** | 4.03±0.17$^{b}$ | 79.71±1.78$^{bc}$ | 0.81±0.16$^{a}$ | 29.68±1.03$^{f}$ |
| | **TWC 353** | 4.25±0.26$^{ab}$ | 75.62±1.26$^{ef}$ | 0.56±0.09a$^{bcd}$ | 41.50±1.32$^{bc}$ |
| | **TWC 354** | 4.30±0.25$^{ab}$ | 74.52±1.18$^{f}$ | 0.43±0.11$^{cd}$ | 42.98±1.09$^{ab}$ |
| **150** | **TWC 324** | 4.23±0.18$^{ab}$ | 79.27±1.12$^{bcd}$ | 0.81±0.15$^{a}$ | 30.94±1.19$^{ef}$ |
| | **TWC 329** | 3.99±0.18$^{b}$ | 78.02±1.20$^{cde}$ | 0.69±0.13$^{abc}$ | 35.12±1.97$^{d}$ |
| | **TWC 353** | 4.20±0.13$^{ab}$ | 74.81±1.91$^{f}$ | 0.62±0.15$^{a\ bc}$ | 44.83±1.76$^{a}$ |
| | **TWC 354** | 4.59±0.36$^{a}$ | 71.96±1.82$^{g}$ | **0.33±0.30**$^{bcd}$ | 41.05±1.88$^{bc}$ |

$TWC_{324}$ and $TWC_{329}$: white corn hybrids - $TWC_{353}$ and $TWC_{354}$: yellow corn hybrids Values are means of three replicates ±SD. Values number in the same raw followed by the same letter are not significantly different at 0.05 levels.

**Nutritionally**

**Chemical composition, caloric, minerals and %RDA of tortilla samples (dry weight basis).**

The Chemical composition, minerals and Nutritional value of tortilla samples /100g for adults are shown in Table (11 and 12). Protein content varies between all samples it could be observed that protein content increased as a result of increasing N fertilizer levels in tortilla samples under 120 to 135 KgN/ fed levels while protein content in level 150 KgN/ fed was significant differed. The highest value amounted in 8.39% TWC354 at level 135 Kg N/ fed which covered about 14.82 and 18.23% of RDA for

male and female adults, respectively. Protein content varies according to different hybrids or endosperm hardness as mentioned **pereir et al (2008).** Crud fat content showed differences in three levels 120,135 and 150 Kg N/ fed. The highest value recorded 4.01, 4.03 and 4.52 g/100g for TWC353 may be due to maize germ increase in weight. The highest value of ash at levels120, 135 and 150 Kg N/ fed being 1.54, 1.41 and 1.40 g/100g for TWC354. Crude fiber content ranged 1.14 to 1.48 was lower than whole grains due to pericarp removal during sieving flour to make tortilla. Total carbohydrates recorded highest value for TWC 324 and TWC329 tortilla samples being 87.10, 86.51, 86.65, 85.60, 85.31 and 86.38 at all levels N fertilizers covered about 67.00, 66.54 and 66.65 % & 65.60, 65.62 and 66.44% of RDA for male and female adults. The highest Calories were recorded in values of 409.81, 409.49, 412.68 TWC353 and TWC354 tortilla samples which covered about 15.76 , 15.74 and 15.87 % for males & 20.49 , 20.47 and 20.63 % for females. The portion, fat, ash and total calorie contents of the studied tortillas were higher than those reported by **Morales and Zepeda (2017)**. The same table showed minerals content (Ca, Fe and Zn) of tortilla prepared from corn hybrids iron and zinc content at 120 N level ranged between 1.75- 2.30 mg/ 100g (TWC354 and TWC324),1.10-1.18 (TWC324and TWC353) and at 135 kg N/ Fed ranged between1.77-1.90 TWC353 and TWC329 and 1.10 -1.16 TWC354 and TWC329 its noticed that white maize contained higher iron than yellow varieties.

Zinc content among tortillas was found in the range of 1.10 to 1.26 for tortilla samples. Tortilla samples covered about 21.88 to 28.75% and 9.72 to12.78% iron for males and females while zinc gave 10.00 to 11.45 % &13.75 to15.75% for males and females of RDA. The results of Fe and Zn were in agreement with those obtained by **Morales and Zepeda (2017).**

Calcium content covered lowest values minerals for tortilla samples which covered between 2.30 to 2.45% of RDA for males and females but were higher than those reported by **Iuga et al (2019).**

## CONCLUSION

Considering all the results presented above, it can be concluded that, application of 135 kg N fed-1 to the maize hybrids TWC 324 and TWC 329 is an optimal for obtaining higher grain yield of maize. Further, it is concluded that more hybrids of maize can be tested for improving the grain yield of maize. In addition, the grain components parts i.e. endosperm, germ and pericarp, resulted in the variation due to the hybrid and N fertilizer level which was in the line with 1000 kernel weight, and grain density during the two seasons. Protein content increase as N level increase. It could be recommended to produce tortilla for celiac disease, where it provides a part of their daily requirements of protein, carbohydrate, calcium, iron and zinc.

**Table 11: Chemical composition, caloric and minerals values of tortilla samples at season 2016 (% dry weight basis).**

| Treatments N (kg Fed$^{-1}$) | Tortilla samples | Protein g/100g | Fat g/100g | Ash g/100g | fiber g/100g | carbohydrates g/100g | T. Calorie kcal | Ca mg/100g | Fe mg/100g | Zn mg/100g |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 2016 | | | | | | | | |
| **120** | TWC 324 | 7.52± 0.38$^{b}$ | 3.06±0.18$^{d}$ | 1.15±0.08$^{ab}$ | 1.18±0.09$^{a}$ | 87.09±1.18$^{a}$ | 405.98±1.98$^{de}$ | 24.21±0.83$^{a}$ | 2.30±0.11$^{a}$ | 1.10±0.11$^{a}$ |
| | TWC 329 | 7.06± 0.59$^{b}$ | 3.66±0.39$^{abcd}$ | 1.36±0.11$^{ab}$ | 1.41±0.11$^{a}$ | 86.51±1.98$^{a}$ | 407.22±2.13$^{cde}$ | 24.25±1.01$^{a}$ | 2.02±0.19$^{b}$ | 1.16±0.08$^{a}$ |
| | TWC 353 | 8.07±0.62$^{a}$ | 4.01±0.42$^{abc}$ | 1.13±0.15$^{b}$ | 1.43±0.21$^{a}$ | 85.37±1.65$^{a}$ | 409.81±1.88$^{abc}$ | 23.18±0.87$^{a}$ | 1.82±0.14$^{b}$ | 1.18±0.13$^{a}$ |
| | TWC 354 | 8.15±0.42$^{a}$ | 3.66±0.54$^{abcd}$ | 1.54±0.19$^{a}$ | 1.28±0.06$^{a}$ | 85.37±1.34$^{a}$ | 407.02±1.98$^{cde}$ | 23.32±0.65$^{a}$ | 1.75±0.09$^{b}$ | 1.14±0.12$^{a}$ |
| **135** | TWC 324 | 7.60±0.35$^{b}$ | 3.15±0.22$^{bcd}$ | 1.40±0.22$^{ab}$ | 1.20±0.13$^{a}$ | 86.65±1.55$^{a}$ | 405.35±1.86 d | 24.43±0.99$^{a}$ | 1.85±0.17$^{b}$ | 1.15±007$^{a}$ |
| | TWC 329 | 8.01±0.87$^{a}$ | 3.63±0.54$^{abcd}$ | 1.28±0.15$^{ab}$ | 1.48±0.10$^{a}$ | 85.60±1.71$^{a}$ | 407.11±2.09$^{cde}$ | 24.34±0.54$^{a}$ | 1.90±0.44$^{ab}$ | 1.16±0.11$^{a}$ |
| | TWC 353 | 8.34±0.47$^{a}$ | 4.03±0.43$^{ab}$ | 1.40±0.23$^{ab}$ | 1.37±0.16$^{a}$ | 84.86±1.43$^{a}$ | 409.07±1.76$^{bcd}$ | 23.15±0.65$^{a}$ | 1.77±0.22$^{b}$ | 1.13±0.32$^{a}$ |
| | TWC 354 | 8.39±0.52$^{a}$ | 4.13±0.29$^{abcd}$ | 1.41±0.43$^{ab}$ | 1.38±0.08$^{a}$ | 84.69±1.65$^{a}$ | 409.49±1.45$^{abc}$ | 23.04±0.79$^{a}$ | 1.85±0.07$^{b}$ | 1.10±0.11$^{a}$ |
| **150** | TWC 324 | 8.30±0.87$^{b}$ | 3.87±0.87$^{b}$ | 1.28±0.21$^{ab}$ | 1.24±0.14$^{a}$ | 85.31±1.87$^{a}$ | 409.27±1.78$^{bcd}$ | 24.50±0.98$^{a}$ | 2.20±0.13$^{a}$ | 1.26±0.21$^{a}$ |
| | TWC 329 | 7.90±0.42$^{ab}$ | 3.12±0.13$^{cd}$ | 1.27±0.14$^{ab}$ | 1.33±0.19$^{a}$ | 86.38±1.43$^{a}$ | 405.20±1.68$^{d}$ | 24.42±0.39$^{a}$ | 2.03±0.21$^{ab}$ | 1.22±0.08$^{a}$ |
| | TWC 353 | 8.22±0.77$^{a}$ | 4.52±0.41$^{a}$ | 1.25±0.23$^{ab}$ | 1.23±0.24$^{a}$ | 84.78±1.69$^{a}$ | 412.68±1.94$^{a}$ | 23.34±0.69$^{a}$ | 2.00±0.13$^{ab}$ | 1.13±0.26$^{a}$ |
| | TWC 354 | 8.23±0.85$^{a}$ | 4.24±0.65$^{a}$ | 1.40±0.05$^{ab}$ | 1.14±0.31$^{a}$ | 84.99±2.09$^{a}$ | 411.04±2.01$^{ab}$ | 23.13±0.54$^{a}$ | 2.01±0.34$^{ab}$ | 1.20±0.33$^{a}$ |

$TWC_{324}$ and $TWC_{329}$: white corn hybrids - $TWC_{353}$ and $TWC_{354}$: yellow corn hybrids. The results are reported as the mean of at least three replications. Means with the same letters in the same row are not significantly different (Tukey $p < 0.05$).

**Table 12: Nutritional Value of tortilla samples /100g for adults.**

| Treatments N (kg Fed$^{-1}$) | Tortilla samples | Protein % RDA | | carbohydrates %RDA | T.Cal .%RDA. | | Ca %RDA | Fe %RDA | | Zn %RDA | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Male | Female | Male & female | Male | Female | Male & female | Male | Female | Male | Female |
| 120 | TWC 324 | 12.61 | 16.34 | 67.00 | 15.62 | 20.30 | 2.42 | 28.75 | 12.78 | 10.00 | 13.75 |
| | TWC 329 | 14.41 | 15.34 | 66.54 | 15.66 | 20.36 | 2.43 | 25.25 | 11.22 | 10.55 | 14.50 |
| | TWC 353 | 14.55 | 17.54 | 65.66 | 15.76 | 20.49 | 2.32 | 22.75 | 10.11 | 10.73 | 14.75 |
| | TWC 354 | 13.57 | 17.72 | 65.66 | 15.65 | 20.35 | 2.33 | 21.88 | 9.72 | 10.36 | 14.25 |
| 135 | TWC 324 | 14.30 | 16.52 | 66.65 | 15.59 | 20.27 | 2.44 | 23.13 | 10.28 | 10.45 | 14.38 |
| | TWC 329 | 14.89 | 17.41 | 65. 60 | 15.65 | 20.36 | 2.43 | 23.75 | 10.56 | 10.55 | 14.50 |
| | TWC 353 | 14.98 | 18.13 | 65.27 | 15.73 | 20.45 | 2.32 | 22.13 | 9.83 | 10.27 | 14.13 |
| | TWC 354 | 14.82 | 18.23 | 65.14 | 15.74 | 20.47 | 2.30 | 23.13 | 10.28 | 10.00 | 13.75 |
| 150 | TWC 324 | 14.11 | 18.04 | 65.62 | 15.74 | 20.46 | 2.45 | 27.50 | 12.22 | 11.45 | 15.75 |
| | TWC 329 | 14.67 | 17.17 | 66.44 | 15.58 | 20.26 | 2.44 | 25.38 | 11.28 | 11.09 | 15.25 |
| | TWC 353 | 14.69 | 17.86 | 65.21 | 15.87 | 20.63 | 2.33 | 25.00 | 11.11 | 10.27 | 14.13 |
| | TWC 354 | 14.97 | 17.89 | 65.37 | 15.81 | 20.55 | 2.31 | 25.13 | 11.17 | 10.91 | 15.00 |

$TWC_{324}$ and $TWC_{329}$: white corn hybrids - $TWC_{353}$ and $TWC_{354}$: yellow corn hybrids. The results are reported as the mean of at least three replications. Means with the same letters in the same row are not significantly different (Tukey $p < 0.05$).

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## الملخص العربي

## استجابه بعض الهجن الثلاثيه للذره الشاميه لمستويات مختلفة من التسميد النيتروجيني وتاثيره على النمو والانتاجية والخواص الفيزوكيميائية والتكنولوجية

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أقيمت تجربه حقليه بمحطه البحوث الزراعية بالجميزه خلال موسم ٢٠١٥ وكررت فى موسم ٢٠١٦ لدراسة استجابة اربعه هجن ثلاثيه للذره الشاميه (ه.ث ٣٢٤, ٣٢٩, ٣٥٣، ٣٥٤) لمعدلات مختلفة من التسميد النيتروجيني (١٢٠، ١٣٥، ١٥٠ كجم نيتروجين / فدان) على نمو محصول الذره الشاميه. وكان تصميم التجربه هو قطاعات منشقه مره واحده في اربعه مكررات. بالاضافة الي دراسة الخصائص الفيزيوكيمائية والتكنولوجية للهجن المنتجة.
وتتلخص اهم النتائج فيما يلي:-
ادت زيادة التسميد النيتروجيني من ١٢٠ الي ١٥٠ كجم نيتروجين / فدان الي التبكير في ظهور النورات المذكرة والمؤنثة، كما أدت الي زياده معنويه في كلا من ارتفاع النبات ومحصول الحبوب بالاردب / فدان في الموسم الثاني بينما لم يكن هناك استجابه معنويه في الموسم الأول في بعض الهجن. كان الهجين الثلاثي ٣٥٣ ابكر الهجن بالنسبه لعدد الأيام من الزراعه حتي ظهور ٥٠% حريره ولقاح وذلك في الموسم الأول بينما في الموسم الثاني كان ه ث ٣٥٤ هو ابكر الهجن. كذلك كان ه ث ٣٢٩ هو الهجين المتأخر في هذه الصفه. وعلي العكس تماما فقد سجل ه ث ٣٢٩ اعلي ارتفاع للنبات بينما سجل ه ث ٣٥٣ اقل ارتفاع للنبات وذلك في كلا الموسمين. سجل كلا من ه ث ٣٢٤, ٣٢٩ اعلي محصول للحبوب بينما ه ث ٣٥٣, ٣٥٤ كلاهما اعطي اقل محصول للحبوب بالاردب للفدان. وكان التفاعل بين الهجن والتسميد النيتروجيني معنويا في صفه محصول الحبوب حيث اعطي ه ث ٣٢٩ اعلي محصول للحبوب بالاردب للفدان في كلا الموسمين بينما اعطي ه ث ٣٥٣ اقل محصول في الموسم الثاني
اظهرت نتائج مكونات الحبة وهي الإندوسبيرم والجنين والقشرة، اختلافا نتيجة اختلاف مستوى التسميد والهجن خلال الموسمين. اظهرت النتائج ايضا زيادة في محتوى البروتين بزيادة معدلات التسميد. تأثر اللون حيث وجد اختلاف معنوي في قيم كلا من L* & b* والكاروتينات الكلية نتيجة اختلاف مستوى التسميد والهجن. سجلت نتائج التقييم الحسي ان التورتيلا المصنعة من هجن الذرة البيضاء (TWC 324, 329)كانت اعلى في القبول العام من تلك المصنعة من هجن الذرة الصفراء (TWC 353, 354) . أظهرت النتائج أيضا أن معامل التشرب للدقيق المستخدم في تصنيع التورتيلا زاد بزيادة معدلات التسميد. غطت التورتيلا المصنعة جزءا من الاحتياجات الموصي بها في RDA من البروتين والكربوهيدرات والكالسيوم والحديد والزنك.