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Evaluation of Extruded Products Prepared from Corn Grits – Corn Starch with Common Carp Fish

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Abstract

The aim of this study was to prepare extruded corn products from 90% yellow corn grits and 10% corn starch with 5, 10 and 15% replacement levels of dried or dried after fried common carp fish at the expense of yellow corn grits. The chemical, physical, sensory properties and microbiological analysis of extruded corn products were evaluated during storage at room temperature for 3 months. Extruded corn products formulated with different replacement levels of carp fish had higher moisture, crude protein, crude fat and energy than control sample. The TVN, TMA, TBA, bulk density, shear force and water absorption index of extruded corn products were increased by increasing the replacement levels of carp fish. However, expansion ratio, water solubility index and total bacterial counts had an opposite trend. Extruded corn products formulated with dried carp fish had higher crude protein TVN, TMA, expansion ratio, water absorption index, water solubility index and total bacterial counts and lower crude fat, energy, TBA, bulk density and shear force than those formulated with dried after fried carp fish. The TVN, TMA, TBA and total bacterial counts of extruded corn products formulated with different replacement levels of carp fish were increased by increasing storage period. Proteolytic bacteria count, lipolytic bacteria count and total yeast and mold did not detect in all samples during storage period. Sensory properties of extruded corn products had rating scores described as like moderately.

Keywords

Corn Grits, Corn Starch, Dried Carp Fish, Dried After Fried Carp Fish, Extruded Corn Products

1. Introduction

Snacks are convenient fast food and their consumption is increasing day by day. It is a food of choice for school children and high movement groups. Most of the snacks available in the market are mainly based of cereals which are high in carbohydrate and low in protein contents. So, the incorporation of high quality protein in these snacks is a good alteration in its nutritional value [1].

Choudhury and Gautam [2] reported that incorporation of fish proteins to starch-rich ingredients such as rice flour reduced expansion and increased hardness. Wianecki [3] reported that muceles of lean fish showed better extrusion characteristics than that of fat fish. Shaviklo et al. [4] reported that snacks fortified with 3, 5 and 7% flesh carp mince had similar sensory properties with better acceptability as compared with control. Shahmohammadi et al. [5] reported that puffed corn-fish snack can be produced from minced silver carp fish at 15% level with desirable expansion ratio, texture and sensory properties.

The objective of this study was to prepare extruded corn products from 90% yellow corn grits and 10% corn starch with different replacement levels of dried or dried after fried common carp fish at the expense of corn grits. The proximate composition, chemical quality characteristics, physical properties, microbiological analysis and sensory properties of extruded corn products were evaluated during storage at room temperature for 3 months.

2. Materials and Methods

2.1. Materials

Common Carp fish (*Cyprinus carpio*) and corn starch were purchased from local markets, Giza, Egypt. Yellow corn grits was obtained from El-Safwa for Food Production Company, El-Kalubiya, Egypt.

2.2. Methods

2.2.1. Preparation of Dried Carp Fish and Dried After Fried Carp Fish

Common carp fishes were washed with water, beheaded, gutted skinned and washed. The skinned carp fishes were filleted manually in iced condition. The carp fillets were divided into two portions. The first portion was ground through a 4 mm plate (dried carp fish). The second portion was covered with wheat flour and fried in oil then ground through a 4 mm plate (dried after fried carp fish). The ground portions were wrapped separately in aluminum foil and autoclaved at 121°C for 20 min and dried in aluminum trays in a conventional oven at 60°C for 12 hr. The dried portions were milled separately (Italmans, motore Asincrono, model TC22, Italy) to pass through 60-mesh sieve.

2.2.2. Preparation of Extruded Corn Products

Control formula was consisted of 90% yellow corn grits and 10% corn starch. To prepare corn grits-corn starch-carp fish formulas, the yellow corn grits in the control formula was replaced with 5, 10 and 15% dried carp fish or dried after fried carp fish. Each formula was prepared by mixing carp fish with corn starch then mixed with yellow corn grits. The moisture content of each formula was adjusted to 16 %. The amount of water was sprayed to each formula then tempered at room temperature overnight to allow the moisture to equilibrate before extrusion process.

Each formula was extruded using a Brabender laboratory single-screw extruder (20 DN) with varied barrel temperature (100, 180 and 180°C for feeding, cooking and die zones, respectively), feed moisture (16%), feeding screw speed (160 rpm), screw compression (4: 1), screw speed (250 rpm) and round die opening (3 mm) according to the method described by Abd El-Hady and Habiba [6]. The extruded products were dried at 110°C for 5 min. The extruded products were packaged separately in polypropylene bags after cooling at room temperature for 2 hr. Extruded corn products were stored at room temperature for 3 months. Samples were taken at specific time intervals for analysis.

2.2.3. Proximate Composition and Energy

AOAC methods [7] were used to determine moisture (method 985.14), crude fat (method 960.39), crude protein (method 992.15) and total ash (method 900.02 A) contents. Total carbohydrates content was calculated by difference. Energy of extruded corn products was calculated on the basis of fat, protein and carbohydrate content.

2.2.4. Total Volatile Nitrogen, Trimethylamine, Thiobarbituric Acid and pH

Total volatile nitrogen (TVN) and trimethylamine (TMA) were determined by the method described by Winton and Winton [8]. Thiobarbituric acid value (TBA) was determined according to the procedure described by Kirk and Sawyer [9]. The pH value was determined using 10% dispersion of extruded corn products in distilled water using a Jenway Digital pH meter (Model 3510).

2.2.5. Physical Properties

i. Expansion ratio

The diameter of ten extruded products was measured with caliper (Dogmatic Micrometer, Miluloyo Company, Japan). Expansion ratio was determined as the ratio of the diameter of the extruded sample to the diameter of the die [10].

ii. Bulk Density

Bulk density of extruded products was reported as g/cm^3 and determined according to the methods described by Park et al. [11] by weighing the quantity required to fill a known volume.

iii. Shear Force

Shear force of the extruded products was measured by using Digital force gauge. (Model FGN-20, Japan). Measurements were made on 10 randomly selected segments of each product.

iv. Water absorption and solubility indices

Water absorption index and water solubility index were determined according to Anderson et al. [12].

2.2.6. Microbiological Analysis

Total bacterial count and psychrophilic bacteria were counted according to the procedure of APHA [13]. Proteolytic bacteria were counted according to the procedure described by Brock [14] and Difco Manual [15]. Lipolytic bacteria were counted according to the methods mentioned by Harrigan and McCance [16] and Difco manual [15]. Yeast and mold were counted according to the procedure of Difco manual [15].

2.2.7. Sensory Evaluation

Sensory properties of extruded corn products were carried out by ten-trained panelists. Randomly coded samples were served to panellists individually. Five sensory attributes were evaluated (color, taste, odor, texture and overall acceptability) using a hedonic scale of nine-points for each trait where 9 = like extremely, 8 = like very much, 7 = like moderately, 6 = like slightly, 5 = neither like nor dislike, 4 = dislike slightly, 3 = dislike moderately, 2 = dislike very much and 1 = dislike extremely.

2.2.8. Statistical Analysis

Proximate chemical composition of raw materials was analyzed by one-way analysis. A completely randomized 4 (replacement levels) × 2 (replacement type) × 4 (storage period) × 3 (replication) factorial design was used for extruded corn products data. An analysis of variance was conducted using Costat version 6.311 (Copyright 1998-2005, CoHort software). When a significant main effect was detected, the means were separated with the Student Newman Keuls test. The predetermined acceptable level of probability was 5% ($P \leq 0.05$) for all comparisons.

3. Results and Discussion

3.1. Proximate Composition and Energy of Raw Materials Used in Extruded Corn Products Preparation

Fresh carp fish had higher moisture than other raw materials and lower ($p \leq 0.05$) protein, fat, ash and energy contents than dried carp fish and dried after fried carp fish (Table, 1). Dried carp fish and dried after fried carp fish had a lower moisture content and higher ($p \leq 0.05$) protein, fat, ash and energy contents than yellow corn grits and corn starch. However, yellow corn grits and corn starch had a higher ($p \leq 0.05$) carbohydrate content than other raw materials. Yellow corn grits had higher moisture, protein, fat and ash contents and lower ($p \leq 0.05$) carbohydrate and energy contents than corn starch. Fresh carp fish and dried carp fish had not carbohydrates content. Similar results were reported by Ćirković et al. [17] and Trbović et al. [18] for carp fillet, Morsy et al. [19] and El-Naggar [20] for yellow corn grits and corn starch.

Table 1. *Proximate composition and energy of raw materials used in extruded corn products preparation.*

(%)	Fresh carp fish	Dried carp fish	Dried after fried carp fish	Yellow corn grits	Corn starch	LSD
Moisture	76.85^{a}	8.12^{d}	6.64^{e}	12.98^{b}	8.97^{c}	0.28
Crude protein	19.76^{c}	82.72^{a}	75.72^{b}	7.97^{d}	0.32^{e}	0.84
Crude fat	2.24^{d}	5.94^{b}	12.75^{a}	3.01^{c}	0.13^{e}	0.27
Total ash	1.15^{c}	3.22^{b}	3.62^{a}	1.32^{c}	0.12^{d}	0.29
Carbohydrates	0.0^{d}	0.0^{d}	1.27^{c}	74.72^{b}	90.46^{a}	1.11
Energy (Kcal)	99.20^{e}	384.34^{b}	422.71^{a}	357.85^{d}	364.29^{c}	3.91

Means in the same row with different letters are significantly different ($p \leq 0.05$)

3.2. Proximate Composition and Energy of Extruded Corn Products

Proximate composition and energy of extruded corn products were affected ($p \leq 0.05$) by different replacement levels of carp fish, but not by storage period (Table, 2). Crude protein, crude fat and energy were affected ($p \leq 0.05$) by replacement types of carp fish, however moisture, total ash and carbohydrates had opposite trend. Singh et al. [1] reported that moisture, fat, protein and ash contents of chicken snacks prepared from spent hen meat and rice flour were not significantly differed during storage at room temperature for 30 days.

Extruded corn products formulated with different replacement levels of carp fish had higher ($p \leq 0.05$) moisture, crude protein, crude fat and energy than control sample which formulated with 90% yellow corn grits and 10% corn starch. Ash content of extruded corn products formulated with 10 and 15% replacement levels of carp fish were higher ($p \leq 0.05$) than control sample, however at 5% replacement level of carp fish were similar to ($p > 0.05$) control sample. These could be attributed to the differences in the proximate chemical composition among dried carp fish, dried after fried carp fish, yellow corn grits and corn starch (Table, 1).

Table 2. *Effect of replacement levels and types of carp fish and storage at room temperature for 3 months on the proximate composition and energy of extruded corn products.*

Treatment	Moisture (%)	Crude protein (%)	Crude fat (%)	Total ash (%)	Carbohydrates (%)	Energy (Kcal)
Replacement levels of carp fish (%)						
0	5.54^{d}	8.91^{d}	3.56^{c}	1.47^{c}	80.31^{a}	388.92^{c}
5	5.64^{c}	11.58^{c}	3.71^{b}	1.54^{bc}	77.75^{b}	390.71^{a}
10	5.74^{b}	15.08^{b}	3.86^{ab}	1.59^{b}	73.74^{c}	390.02^{b}
15	5.84^{a}	18.48^{a}	3.95^{a}	1.69^{a}	70.22^{d}	390.35^{ab}
LSD	0.08	0.47	0.13	0.09	0.38	0.65
Replacement types of carp fish						
Dried	5.72^{a}	13.77^{a}	3.56^{b}	1.56^{a}	75.39^{a}	388.67^{b}
Dried after fried	5.66^{a}	13.25^{b}	3.89^{a}	1.59^{a}	75.62^{a}	390.45^{a}
LSD	0.08	0.33	0.09	0.06	0.27	0.35
Storage period (months)						
0	5.73^{a}	13.56^{a}	3.83^{a}	1.55^{a}	75.34^{a}	390.00^{a}
1	5.71^{a}	13.52^{a}	3.69^{a}	1.56^{a}	75.52^{a}	389.39^{a}
2	5.68^{a}	13.5^{a}	3.70^{a}	1.58^{a}	75.55^{a}	389.49^{a}
3	5.66^{a}	13.46^{a}	3.67^{a}	1.60^{a}	75.61^{a}	389.36^{a}
LSD	0.08	0.47	0.17	0.09	0.38	0. 67

Means in the same column with different letters are significantly different ($p \leq 0.05$)

There were no differences ($p > 0.05$) in moisture, total ash and carbohydrates between extruded corn products formulated with dried carp fish and those formulated with dried after fried carp fish. However, extruded corn products formulated with dried carp fish had higher ($p \leq 0.05$) crude protein and lower crude fat and energy than those formulated with dried after fried carp fish. Data in Table (1) supported these results.

3.3. Chemical Quality Characteristics and pH Values of Extruded Corn Products

The TVN, TMA and TBA values of extruded corn products were affected ($p \leq 0.05$) by different replacement levels and types of carp fish and storage period. However, pH values of extruded corn products were not affected ($p \leq 0.05$) by different replacement levels and types of carp fish and storage period (Table, 3).

The TVN, TMA and TBA values of extruded corn products formulated with different replacement levels of carp fish were increased ($p \leq 0.05$) by increasing replacement levels of carp fish. The increment of TVN, TMA and TBA values were in the range 444.83-756.65 mg/100g, 314.00-670.00 mg/100g and 44.66-94.25 mg malonaldehyde/kg, respectively.

The TVN and TMA values of extruded corn products formulated with dried carp fish were higher ($p \leq 0.05$) than those formulated with dried after fried carp fish. However, extruded corn products formulated with dried carp fish had a lower ($p \leq 0.05$) TBA values than those formulated with dried after fried carp fish. Data in Table (1 and 2) supported these results.

The TVN, TMA and TBA values of extruded corn products formulated with different replacement levels of carp fish were increased ($p \leq 0.05$) by increasing storage period. The increment of TVN, TMA and TBA values were in the range 22.14-101.16 mg/100g, 61.19-165.67 mg/100g and 30.79-68.72 mg malonaldehyde/kg, respectively. These results differed from those reported by Singh et al. [1] who found that TBA values of chicken snacks prepared from spent hen meat and rice flour were not differed during storage at room temperature for 30 days.

Table 3. *Effect of replacement levels and types of carp fish and storage at room temperature for 3 months on the chemical quality characteristics and pH values of extruded corn products.*

Treatment	TVN (mg/100g)	TMA (mg/100g)	TBA (mg malonaldehyde/kg)	pH
Replacement levels of carp fish (%)				
0	2.03^{d}	0.00^{d}	0.365^{d}	6.31^{a}
5	11.06^{c}	3.14^{c}	0.528^{c}	6.32^{a}
10	14.85^{b}	5.04^{b}	0.609^{b}	6.25^{a}
15	17.39^{a}	6.70^{a}	0.709^{a}	6.23^{a}
LSD	0.86	0.40	0.04	0.26
Replacement types of carp fish				
Dried	12.15^{a}	3.93^{a}	0.512^{b}	6.27^{a}
Dried after fried	10.51^{b}	3.51^{b}	0.594^{a}	6.27^{a}
LSD	0.61	0.28	0.03	0.18
Storage period (months)				
0	7.77^{d}	2.01^{d}	0.406^{d}	6.23^{a}
1	9.49^{c}	3.24^{c}	0.531^{c}	6.26^{a}
2	12.45^{b}	4.29^{b}	0.588^{b}	6.28^{a}
3	15.63^{a}	5.34^{a}	0.685^{a}	6.33^{a}
LSD	0.86	0.4	0.04	0.26

Means in the same column with different letters are significantly different ($p \leq 0.05$)

3.4. Physical Properties of Extruded Corn Products

Physical properties of extruded corn products were affected ($p \leq 0.05$) by different replacement levels and types of carp fish. However, physical properties of extruded corn products were not affected ($p \leq 0.05$) by storage period (Table, 4). Expansion ratio of extruded corn products was decreased ($p \leq 0.05$) by increasing the replacement levels of carp fish. However, bulk density and shear force were increased ($p \leq 0.05$) by increasing the replacement levels of carp fish. Similar observations were reported by Osheba and Nagy [21] and Shahmohammadi et al. [5].

The decrease of expansion ratio and increase of bulk density and shear force may be attributed to increasing the replacement levels of carp fish which increase moisture and crude protein contents and decrease carbohydrate content of extruded corn products (Tables, 2). Rehrah et al. [22] reported a negative relation between protein amount and expansion ratio of extruded products. Reduction of expansion ratio with increasing bulk density and hardness of extruded products due to the addition of muscle and fish protein was also reported by Shahmohammadi et al. [5]. On the other hand, expansion ratio of extruded corn products formulated with dried carp fish were higher ($p \leq 0.05$) than those formulated with dried after fried carp fish. However, bulk density and shear force in extruded corn products formulated with dried carp fish were lower ($p \leq 0.05$) than those formulated with dried after fried carp fish.

Table 4. *Effect of replacement levels and types of carp fish and storage at room temperature for 3 months on the physical properties of extruded corn products.*

Treatment	Expansion ratio	Bulk density (g/cm^3)	Shear force (Newton)	Water absorption index (%)	Water solubility index (%)
Replacement levels of carp fish (%)					
0	3.42^a	0.284^d	6.28^d	5.10^d	19.92^a
5	3.17^b	0.33^c	8.84^c	5.60^c	19.18^b
10	3.09^c	0.40^b	10.15^b	6.12^b	17.22^c
15	2.60^d	0.449^a	11.09^a	6.51^a	15.17^d
LSD	0.07	0.04	0.41	0.35	0.67
Replacement types of carp fish					
Dried	3.11^a	0.353^b	8.77^b	6.01^a	18.06^a
Dried after fried	2.94^b	0.379^a	9.41^a	5.65^b	17.69^b
LSD	0.05	0.03	0.29	0.24	0.31
Storage period (months)					
0	3.08^a	0.358^a	8.93^a	5.94^a	18.05^a
1	3.05^a	0.361^a	9.04^a	5.89^a	17.97^a
2	3.01^a	0.367^a	9.14^a	5.81^a	17.82^a
3	2.97^a	0.377^a	9.26^a	5.70^a	17.66^a
LSD	0.12	0.04	0.41	0.35	0.67

Means in the same column with different letters are significantly different ($p \leq 0.05$)

Water absorption index was increased ($p \leq 0.05$) by increasing the replacement levels of carp fish. However, water solubility index had an opposite trend. Similar results were reported by Osheba and Nagy [21] for extruded corn fortified with three levels of dried camel meat or dried chicken breast meat. Positive relations were found among crude protein, moisture and water absorption index of extruded corn products. However, inverse relationship was found between carbohydrates content and water absorption index of extruded corn products (Table, 2). On contrary, water solubility index had opposite trend with protein, moisture and carbohydrate contents (Table, 2).

Water absorption index and water solubility index of extruded corn products formulated with dried carp fish were higher ($p \leq 0.05$) than those formulated with dried after fried carp fish. This might be due to the extruded corn products formulated with dried carp fish had a lower ($p \leq 0.05$) crude fat content than those formulated with dried after fried carp fish (Table, 2).

3.5. Microbiological Analysis of Extruded Corn Products

Data in Table (5) showed that total bacterial counts of extruded corn products were gradually reduced from 2.46 to 2.26 log cfu/g by increasing replacement levels of carp fish. Dried after fried carp fish was more effective in reducing total bacterial counts compared with dried carp fish. Total bacterial counts of extruded corn products were gradually increased by increasing the storage period.

Table 5. *Total bacterial count log (cfu/g) of extruded corn products as affected by different replacement levels and types of carp fish and storage at room temperature for 3 months.*

Treatment	Storage period (months)			
	0	1	2	3
Control	2.46	2.51	2.53	2.57
Dried carp fish				
5	2.41	2.49	2.54	2.59
10	2.36	2.45	2.51	2.56
15	2.28	2.38	2.45	2.51
Dried after fried carp fish				
5	2.38	2.46	2.52	2.57
10	2.34	2.43	2.49	2.54
15	2.26	2.36	2.43	2.49

Proteolytic bacteria count, lipolytic bacteria count and total yeast and mold of extruded corn products did not detect in all samples. The present results were lower than of the permissible level reported by Egyptian Standard [23] which stated that, total aerobic bacterial count and total yeast and mold counts in popcorn products should not exceed 4 and 2 log cfu/g, respectively. Singh et al. [1] found that total bacterial count and total yeast and mold of chicken snacks prepared from spent hen meat and rice flour were increased from day 6 to 30 and from 24 to 30 of storage at room temperature, respectively.

3.6. Sensory Properties of Extruded Corn Products

Sensory properties of extruded corn products were affected ($p \leq 0.05$) by different replacement levels and types of carp fish and storage period (Table, 6). Taste of extruded corn products was increased ($p \leq 0.05$) by increasing replacement levels of carp fish. However, color crispiness, chewiness and pore distribution had opposite trend. Extruded corn formulated with 5 and 10% carp fish had higher ($p \leq 0.05$) surface characteristics than extruded corn control extruded corn formulated with15% carp fish. No significant ($p > 0.05$) difference was observed in surface characteristics between control and extruded corn formulated with15% carp fish. On the other hand, no significant ($p > 0.05$) difference was found in overall acceptability among extruded corn products.

Extruded corn formulated with dried after fried carp fish had higher ($p \leq 0.05$) taste, crispiness, chewiness, surface characteristics and overall acceptability scores than extruded corn formulated with dried carp fish. However, extruded corn formulated with dried carp fish had higher ($p \leq 0.05$) pore distribution score than extruded corn formulated with dried after fried carp fish. The color was similar ($p > 0.05$) in both products.

Table 6. *Effect of replacement levels and types of carp fish and storage at room temperature for 3 months on the sensory properties of extruded corn products.*

Treatment	Taste	Color	Crispiness	Chewiness	Pore distribution	Surface characteristics	Overall acceptability
Replacement levels of carp fish (%)							
0	6.81^{d}	8.41^{a}	8.08^{a}	7.94^{a}	7.97^{a}	7.35^{c}	7.73^{a}
5	7.45^{c}	7.96^{b}	7.82^{b}	7.54^{b}	7.76^{b}	8.02^{a}	7.75^{a}
10	7.84^{b}	7.74^{c}	7.70^{c}	7.36^{c}	7.58^{c}	7.70^{b}	7.67^{a}
15	8.28^{a}	7.57^{d}	7.52^{d}	7.16^{d}	7.40^{d}	7.45^{c}	7.60^{a}
LSD	0.11	0.14	0.11	0.15	0.15	0.15	0.15
Replacement types of carp fish							
Dried	7.29^{b}	7.96^{a}	7.68^{b}	7.41^{b}	7.79^{a}	7.54^{b}	7.60^{b}
Dried after fried	7.90^{a}	7.88^{a}	7.88^{a}	7.58^{a}	7.55^{b}	7.72^{a}	7.77^{a}
LSD	0.08	0.10	0.07	0.10	0.10	0.11	0.12
Storage period (months)							
0	7.77^{a}	8.26^{a}	7.99^{a}	7.77^{a}	7.90^{a}	7.86^{a}	7.92^{a}
1	7.67^{a}	8.04^{b}	7.85^{b}	7.63^{a}	7.74^{b}	7.70^{b}	7.78^{a}
2	7.53^{b}	7.82^{c}	7.72^{c}	7.39^{b}	7.61^{b}	7.58^{b}	7.61^{b}
3	7.39^{c}	7.56^{d}	7.55^{d}	7.20^{c}	7.45^{c}	7.38^{c}	7.43^{c}
LSD	0.11	0.14	0.11	0.15	0.15	0.15	0.15

Means in the same column with different letters are significantly different ($p \leq 0.05$)

Color crispiness, pore distribution and surface characteristics of extruded corn products were decreased ($p \leq 0.05$) by increasing storage period. Taste, chewiness and overall acceptability of extruded corn products did not differ up one month of storage followed by decrease in their scores up to the end of storage period. Although sensory properties of extruded corn products reduced during storage period, their overall acceptability rating scores described as like moderately (7.43-7.92). Singh et al. [1] reported that the sensory properties scores of chicken snacks prepared from spent hen meat and rice flour were reduced during storage at room temperature for 30 days.

4. Conclusions

From the above results, it could be concluded that crude protein of extruded corn products increased from 8.91% to 18.48% by replacing yellow corn grits with 15% carp fish. TVN, TMA and TBA increased by increasing replacement levels of carp fish but their values were within the acceptable range of fish products. Expansion ratios and total bacterial count of extruded corn products reduced by increasing the replacement levels of carp fish and their reduction ranged from 7.31 to 23.98% and 2.03-8.13%, respectively. Proximate composition and physical properties did not affected by storage period. However, TVN, TMA, TBA and total bacterial count had an opposite trend. Sensory properties of extruded corn products reduced during storage period, but their rating scores described as like moderately.

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