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UTILIZATION OF SOME FOOD INDUSTRIES BY-PRODUCTS TO PRODUCE HIGH FIBER, HIGH PROTEIN RICE-BASED EXTRUDATES

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ABSTRACT

Three food industries by-products; barley mash, corn gluten feed and corn gluten meal were used to produce high fiber, high protein rice-based extrudates. Barley mash and corn gluten feed characterized by high fiber (10.41 and 11.34%) and high ash (4.63 and 6.43%) content. While, corn gluten meal characterized by high protein (60.25%) contents. These by-products were added by 5, 10, 20 and 30% in order to enhance the fiber and protein contents in the resultant rice-based extrudates. Effects of adding these ingredients on the expansion ratio (ER), bulk density (BD), water absorption index (WAI), water solubility index (WSI), breaking strength (BS), color, chemical composition, minerals content and sensory evaluation of the resultant extrudates were evaluated. The obtained results indicated that adding barley mash alone or as a mixture with gluten meal, and corn gluten feed decreased the ER, WSI, WAI, BS and L^* values of the products, while increased the BD. Incorporation gluten meal caused increase in ER and b^* values of the products. Chemical composition and minerals contents were depending upon the composition of the ingredients and substitution ratios. Sensory evaluation indicated that high fiber; high protein extrudates with acceptable quality could be prepared from barley mash alone or as a mixture with gluten meal, corn gluten feed or meal up to 10%.

Keywords: Extrusion, barley, corn gluten feed, corn gluten meal, functional properties, sensory evaluation, by-products

INTRUDCTION

High-temperature, short time (HTST) extrusion cooking technology has almost limitless application in the processing of cereal-based products of various blends for food as well as feed. It is an effective method to pre-cook grains and flours. It is applied in many food production processes, such as starch depolymerization, manufacture of snack foods, baby foods, pasta products and textured vegetable protein, where the starchy and proteinaceous raw materials were converted into fabricated products. The major application includes the production of breakfast cereals and snacks (Hakulin *et al.*, 1983; Abbott, 1987; Dziezak, 1989; Jin *et al.*, 1994; Konstance *et al.*, 1998 and Rhee *et al.*, 1999).

Snacks and breakfast cereals are essentially produced from starchy substances such as corn, rice, wheat, oat, which are poor sources of protein, sugars, dietary fiber and minerals. These raw materials can be incorporated into a formulation with many other minor ingredients; such as emulsifiers, fats & oils, sugars, salt, fibers, vitamins, proteins and minerals; to change the chemical, physical, sensory and nutritional properties of the product (Linko *et al.*, 1981; Hsieh *et al.*, 1991, Abd El-Hady *et al.*, 1997, 2000 and Abd El-Hady *et al.* 2002).

Recently, increasing attention has been directed to incorporated dietary fiber into food (Colonna *et al.*, 1989). There are many medical benefits related to dietary fiber presence in meals; decrease lymphatic absorption of cholesterol, bind bile acids and bile salts in vitro, protect against chemically induced cancer; control glucose levels in blood and reduce the daily insulin dose of diabetics, helping weight reduction and physical gastrointestinal tract disorders (Gordon, 1989 and Stauffer, 1993). Many investigations were carried out to offer consumers good extruded products with the beneficial dietary fiber using complex recipes (Andersson *et al.*, 1981; Bjorck *et al.*, 1984; Lue *et al.*, 1991; Berglund *et al.*, 1994; Jin *et al.*, 1994; Abd El-Hady *et al.*, 2000 and Yaseen *et al.*, 2001).

As most snacks and breakfast cereals are poor sources of protein, which has low nutritional quality, the protein supplementation is needed. Many applications were done to increase the nutritional value of many food snacks using high biological value ingredients in formulated mixtures (Almeida-Dominguez *et al.*, 1990; Saleh, 1996; Abd El-Hady *et al.*, 1997 and 1999).

Now-days, there are very interest to maximize the utilization of food sources and use the food industry by-products in new value-added products. Most of food industry by-products were disposed of, sold for sub-market prices or used for animal feeding. Most of these by-products are rich in fibers, proteins and minerals. So, many recent investigations were done to use these materials to produce high nutritional and special foods. Rice bran, soy fiber, oat fiber, pea fiber, sugar beet fiber, apple pomace, barley husks, orange fiber and potato peels were used to produce high dietary fiber extrudates (Bollinger, 1996; Singh *et al.*, 2000; Abd El-Hady *et al.*, 2000a and Yaseen *et al.*, 2001). Also, Kee *et al.* (2001) studied the physical properties of extruded snack made of onion pomace; a by-product of onion processing; with corn grits.

Many researchers investigated the extrusion of protein-rich animal or fish by-products. Roseg *et al.* (1991) discussed the utilization of protein-rich meat fish by-products for manufacture of edible extrudates. Murphy *et al* (2003) and Obatolu *et al* (2005) studied the chemical composition and physical properties of extruded snacks containing crab-processing and crustacean by-products.

Therefore, the aim of the present work is to produce a high fiber, high protein extrudates utilizing some of food industry by-products to increase its nutritional and economical values.

MATERIALS AND METHODS

Materials

1-Barley mash (Malt sprouts); consists of dried sprouts and rootlets produced from malting of barley for beer production rich in crude fiber and ash contents was obtained from El-Ahram Company for Beverage, Giza, Egypt..

2-Corn gluten feed (shelled corn remains after the extraction of the larger portion of starch, gluten and germ from the wet milling manufacture of corn starch and syrup) and corn gluten meal (dried residue from corn after removal of the larger part of the starch and germ and separation of the bran) were obtained from National Company for Maize Products, 10^{th} of Ramadan City, Egypt. Rice and dry skim milk (DSM) were purchased from local market at Ismailia governorate. Rice was ground to get homogenous particles size by using a laboratory mill (Brabender Automat Mill Quandrumat Senior, Germany), then used to prepare different blends.

Methods

1- Extrusion

Four mixtures at levels of 5, 10, 20 and 30% of barley mash, corn gluten feed and meal and mixture of barley mash: corn gluten meal (1: 1) with rice grits were extruded using a Brabender laboratory single-screw extruder (20 DN) with varied barrel temperature (130, 180 and 160 °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 (3mm) according to the method described by Abd El-Hady and Habiba (2003). The resultant extrudates were dried at 110 °C for 5 min and were allowed to reach room temperature, then subjected for different analyses. The preferable blends after sensory evaluation were supplemented by adding 1% dry skim milk (DSM) as a standard protein.

2- Physical and functional properties

Expansion ratio (ER), the ratio of the cross-sectional diameter of the extrudate sticks to the die exit diameter, was determined according to Gomez and Aguilera (1984). The bulk density (BD, g /$100cm^3$) was carried out by weighing the quantity required to fill a known volume. Water absorption index (WAI), the amount of gel formed per gram extrudate, and water solubility index (WSI), the fraction of dry sample, which was soluble, were determined as described by Anderson *et al.* (1969). Breaking strength (BS) was measured by using Brabender Struct-o-graph according to Abd El-Hady *et al.* (1997). Color attributes of the extrudates were determined by Minolta Color Reader, Mo, CR10, Japan. Where, L^*, a^*, and b^* values were measured after ground the extrudates.

3- Chemical composition

Moisture content, crude protein (N* 5.7), ether extract, crude fiber and ash contents were determined as described in the AOAC (1995). Total carbohydrate contents were calculated by difference. Contents of some minerals (K, Ca, Mg, Fe, Mn and Zn) were determined according to AOAC (1995) by wet ashing and using Atomic Absorption Spectrophotometer Varian AA20 (Cottenie, *et al.* 1982).

4- Sensory evaluation

The sensory evaluation of the extrudates was carried out by staff members and semi-trained panelists for taste (20), crispness (20), chewiness

(15), odor (15), color (10), pore distribution (10) and surface characteristics (10). The overall acceptability of the samples was calculated, from the total scores of tested attributes and grades were given according to the following scale: excellent (86-100), good (76-85), fair (61-75) and poor (< 60) as described by Kramer and Twigg (1970).

5- Statistical analysis

The analysis of variance (ANOVA) was carried out to test the possibility of significant of treatment effect. LSD as described by Ott (1984) was used to perform all possible pair comparisons between means of different treatments.

RESULTS AND DISCUSSION

1- Chemical composition:

The chemical composition of the ingredients, which used in this work, is shown in Table (1). Uses of food industries by-products, high in fibers and or protein, in food technology may serve as an economical target.

Table (1). Chemical composition* (%) of the ingredients (on dry basis).

Ingredients	Moisture	Total carbohydrates**	Protein	Crude fiber	Ether extract	Ash
Rice grits	12.8^{b}	89.37^{a}	8.14^{e}	0.26^{d}	1.79^{d}	0.44^{e}
Barley mash	8.7^{d}	39.82^{d}	36.06^{c}	10.41^{b}	9.08^{a}	4.63^{c}
Corn gluten feed	11.3^{c}	58.15^{b}	20.15^{d}	11.34^{a}	3.93^{c}	6.43^{b}
Corn gluten meal	13.7^{a}	30.09^{e}	60.25^{a}	2.21^{c}	6.15^{b}	1.30^{d}
Dry skim milk (DSM)	5.2^{e}	50.83^{c}	39.04^{b}	-	1.33^{d}	8.80^{a}

*Means of triplicates
**Calculated by difference
Means having the same letter with each property are not significantly different at $p \leq 0.05$

2- Physical and functional properties of extrudates

2.1- Expansion ratio (ER):

The data presented in Table (2) showed that the ER of the produced extrudates significantly decreased by adding barley mash, corn gluten feed and the mixture of barley mash and corn gluten meal. Where, it decreased from 3.01 for the rice grits (base formula) to 1.50, 2.35 and 2.24 for the extrudates containing 30% of barley mash, corn gluten feed and the mixture of barley mash and corn gluten meal, respectively. Barley mash displayed the great reduction in expansion even at low concentration (5%). The undesirable effect on ER may be due to the presence of fiber. These results are in agreement with those obtained by Moore *et al.*(1990); Lue *et al.*, (1991); Mohi El-Din, (1998) and Yaseen *et al.*, (2001). In this point, Guy (1985) reported that bran particles caused premature rupture of gas cells, which reduced overall expansion. Also, Hsieh *et al.* (1989 and 1991) found that increasing fiber content increased the axial expansion but decreased the radial expansion. The net results were a decrease in the expansion.

On the other hand, the expansion ratio of the extrudates containing corn gluten meal significantly increased up to 20% substitution. This may be due to the corn gluten expanded more than rice starch. Faubion *et al.* (1982)

reported that addition of soy protein isolate (up to 8%) to wheat starch caused an increase in expansion, whereas similar levels of added wheat gluten caused a reduction in expansion.

Adding 1% of dry skim milk (DSM) to blends containing 10% of the tested materials caused slightly changes in ER of the produced extrudates (Table, 2).

Table (2). Effect of adding some food industries by products on the physical and functional properties of rice-based extrudates

Extrudate type	ER	BD (g/100Cm^3)	WSI %	WAI gg^{-1}	BS (Bu)	Color attributes L*	a*	b*
Rice grits (Control)	3.01^a	35.11^d	25.48^a	8.39^a	520^a	78.5^a	3.4^e	11.0^b
Barley mash, 5%	2.33^b	45.03^c	10.30^b	6.42^c	520^a	70.6^b	6.4^d	13.8^a
10%	2.26^{b,c}	49.15^b	8.64^{b,c}	6.89^b	492^b	69.4^b	7.1^c	13.7^a
20%	2.13^d	53.98^a	6.43^{c,d}	5.27^e	518^a	64.1^{c,d}	7.8^b	14.7^a
30%	1.50^e	54.48^a	5.34^d	4.86^f	509^a	60.4^d	8.0^a	14.2^a
10%+1% DSM	2.22^{c,d}	54.16^a	8.68^{b,c}	5.95^d	519^a	68.0^{b,c}	7.3^c	14.4^a
Rice grits (Control)	3.01^b	35.11^c	25.48^c	8.39^a	520^a	78.5^a	3.4^d	11.0^c
Corn gluten feed, 5%	3.13^a	34.18^d	31.41^{a,b}	7.71^b	495^b	74.5^{a,b}	5.1^c	15.8^b
10%	3.03^{a,b}	35.87^c	30.72^b	7.33^{c,d}	478^c	72.3^b	5.3^c	15.7^b
20%	2.47^c	38.41^b	33.35^{a,b}	7.04^{d,e}	142^e	67.8^{c,d}	6.2^b	17.5^a
30%	2.35^d	40.94^a	32.62^{a,b}	6.79^e	65^f	65.6^d	7.0^a	18.6^a
10%+1% DSM	3.04^{a,b}	34.76^{c,d}	34.43^a	7.51^{b,c}	423^d	71.1^{b,c}	6.6^{a,b}	19.2^a
Rice grits (Control)	3.01^e	35.11^a	25.48^b	8.39^a	520^a	78.5^a	3.4^d	11.0^c
Corn gluten meal, 5%	3.22^d	34.14^{a,b}	30.12^a	7.79^b	494^b	75.5^a	5.2^c	26.3^b
10%	3.59^b	33.22^{a,b}	30.19^a	7.12^c	485^b	70.7^b	6.5^b	28.8^a
20%	3.68^a	29.26^c	26.31^b	6.05^d	411^d	68.2^b	7.6^a	30.8^a
30%	3.58^b	29.51^c	25.80^b	5.33^e	232^e	66.8^b	8.0^a	30.6^a
10%+1% DSM	3.50^c	32.31^b	30.73^a	6.91^c	468^c	70.8^b	7.7^a	29.4^a
Rice grits (Control)	3.01^a	35.11^{c,d}	25.48^a	8.39^a	520^a	78.5^a	3.4^e	11.0^c
Barley mash + Corn gluten meal (1:1), 5%	3.00^{a,b}	33.23^d	21.60^{b,c}	7.34^b	502^b	73.5^b	5.5^d	21.0^b
10%	2.95^b	35.61^{b,c}	24.63^{a,b}	6.54^c	457^c	71.2^b	6.8^c	23.9^a
20%	2.62^d	36.43^{b,c}	21.41^c	5.86^d	266^f	69.6^{b,c}	7.3^b	24.3^a
30%	2.24^e	41.31^a	9.95^d	5.33^e	424^e	65.3^c	7.8^{a,b}	24.4^a
10%+1% DSM	2.82^c	37.60^{a,b}	26.97^a	6.67^c	442^d	71.4^b	7.9^a	24.2^a

Bu= Brabender unit.
Means having the same letter with each property are not significantly different at $p \leq 0.05$.

2.2- Bulk density (BD)

The bulk density (BD) of the extrudates was revealed an opposite trend to that discussed for the ER. If expansion increased, it would be logical to assume the BD would decrease, under the same conditions. Thus, the results in Table (2) indicated that adding barley mash alone or as a mixture with corn gluten meal (1:1) and corn gluten feed increased significantly the BD of the extrudates. The highest increased of BD was noticed in the extrudates containing barley mash, even at low concentration (5%). The high values of BD in extrudates, which contained fiber, may be due to its violent effect on starch gelatinization and on the cell wall also. These results agreed with those esults, which obtained by Moore *et al.* (1990), Jin *et al.* (1994), Abd El-Hady *et al.* (2000) and Yaseen *et al.* (2001).

On contrary, adding corn gluten meal to produce high protein extrudates cause a significant decrease in BD. Where, the BD decreased from 35.11 g 100 cm^{-3} for base formula to 29.51 g 100 cm^{-3} for that containing 30% corn gluten meal. Meuser and Wiedmann (1989) reported the addition of casein to wheat starch decreased the extrudates bulk density because casein expanded more than wheat starch. While, Martinez-Serna and Villota (1992) observed a 30% decrease in extrusion expansion with the addition of 10% whey protein isolate to corn starch.

2.3- Water absorption index (WAI) and water solubility index (WSI)

From the same Table (2), it was noticed that WAI significantly decreased by adding all the additives materials. The WAI decreased from 8.39 g water g^{-1} extrudates in base formula to 4.86, 6.79, 5.33 and 5.33 in the extrudates containing 30% of barley mash, corn gluten feed, corn gluten meal and that contains 30% of the mixture of barley mash and gluten meal (1:1), respectively. These results confirmed those were reported by many investigators such as Berglund *et al.* (1994), Abd El-Hady *et al.* (1997, 1999, 2000), Yaseen *et al.* (2001) and Abd El-Hady (2002).

Regarding the WSI values, it significantly decreased by adding barley mash alone or as a mixture with gluten meal (1: 1). The WSI decreased from 25.48% in the base formula to 5.34 and 9.95% in the extrudates containing 30% barley mash and mixture of barley mash and gluten meal, respectively. As the fiber materials increased, the starchy material contents decreased, causing a reduction in soluble starchy materials (Berglund *et al.*, 1994 and Yaseen *et al.*, 2001). On the other hand, adding corn gluten feed (fiber source) or corn gluten meal (protein source) caused significantly increased in WSI up to 20%, then non-significantly decreased in the extrudates containing 30% from these materials. That is may be because that the composition is different from source to the other (Yaseen *et al.*, 2001). The WSI of the extrudates increased by adding legumes to rice, and the increment was owing to the degradation of starchy materials in blends by extrusion process (Hussein, 1987 and Abd El-Hady *et al.*, 1997).

By adding 1% DSM to blends which containing 10% of the tested materials, no distinct changes in WSI values were observed.

2.4- Breaking strength (BS)

The data in Table (2) showed that BS of the extrudates significantly decreased by adding both of corn gluten feed and meal. It decreased from 520 Bu for base formula (rice grits) to 65 and 232 Bu in the extrudates contained 30% gluten feed or meal, respectively. The same observation was noticed in the extrudates containing a mixture of barley mash and gluten meal up to 20% (266 Bu). Adding barley mash alone cause slightly changes in the BS compared with the base formula. Abd El-Hady *et al.* (1997) reported that the texture of the extruded products is related to the type and quantity of starch, protein materials in products. The BS decreased by adding legumes. This is due to the higher protein content in extrudates comparable with base product. Also, Yaseen *et al.* (2001) showed that the BS values of the extrudates varied depending on the type and level of fiber in blends.

2.5- Color of the extrudates

The effect of adding used materials on the color properties of rice extrudates is presented in Table (2). A noticed difference of extrudates color was reported. Adding tested materials reduced lightness (L^*) values. This lightness reduction was more pronounced in barley mash (fiber source) enriched extrudates. These results are in agreement with those obtained by Arora *et al.* (1993), Jin *et al.* (1994) and Yaseen *et al.* (2001).

Comparison among a^* values (degree of redness) of extrudates indicated that extrudates prepared using barley mash and corn gluten meal within the tested range were clearly more red than extrudates prepared using rice grits only. Values of b^* (degree of yellowness) also, increased by adding tested materials. The highest b^* values were observed in the extrudates, which contained corn gluten meal. This due to the high yellow color of the gluten meal. So, the color attributes of the extrudates were influenced by the initial color of the raw materials and extrusion process.

3- Chemical composition of the extrudates

Table (3) shows the chemical composition of extrudates prepared from rice grits with the added materials. It is obvious that, barley mash incorporation significantly increased the moisture content of the extrudates compared with that of base formula. This is may be explained by the fact that fibers tend to retain water in the product. An opposite trend was noticed with other additives. Abd El-Hady *et al.* (1997) showed that increased legumes in base formula decreased moisture content in the extrudates.

The data showed that, increasing the addition rate of fiber containing materials (barley mash and gluten feed) or protein-containing material (gluten meal) in recipes successively increased the crude fiber and protein contents in the resultant extrudates. The crude fiber content increased from 0.18% for base formula to 3.15, 1.98 and 3.45% for the extrudates containing 30% of barley mash alone or as a mixture with gluten meal and gluten feed, respectively.

The highest increase in protein content was observed in the extrudates containing gluten meal. It increased from 8.02% for base formula to 23.69% in the extrudate contains 30% corn gluten meal.

With regard to the other components of extrudates samples, variations, depend upon the composition of the ingredients and substitution ratios. Where, the ether extract and ash contents increased with increasing additives. As a result of increasing of protein, crude fiber and other components contents in the produced extrudates, the carbohydrate contents decreased as shown in Table (3).

Table (3): Effect of adding some food industries by products on the chemical composition* (%) of rice-based extrudates

Extrudate type	Moisture	Total carbohydrates**	Protein	Crude fiber	Ether extract	Ash
Rice grits (Control)	8.7^{c}	89.49^{a}	8.02^{e}	0.18^{e}	1.57^{c}	0.74^{e}
Barley mash, 5%	9.5^{a}	$87.19^{a,b}$	$9.52^{d,e}$	0.61^{d}	1.72^{c}	0.96^{d}
10%	9.1^{b}	84.48^{b}	$11.00^{c,d}$	1.20^{c}	$2.10^{b,c}$	1.22^{c}
20%	9.7^{a}	79.80^{c}	13.70^{b}	2.03^{b}	$2.85^{a,b}$	1.62^{b}
30%	9.1^{b}	74.93^{d}	16.43^{a}	3.15^{a}	3.62^{a}	1.87^{a}
10%+1% DSM	8.7^{c}	83.86^{b}	11.74^{c}	1.08^{c}	$2.03^{b,c}$	1.29^{c}
Rice grits (Control)	8.7^{b}	89.49^{a}	8.02^{d}	0.18^{e}	1.57^{a}	0.74^{e}
Corn gluten feed, 5%	9.1^{a}	$87.77^{a,b}$	8.74^{c}	0.73^{d}	1.69^{a}	1.07^{d}
10%	8.5^{b}	$85.90^{b,c}$	$9.61^{b,c}$	1.29^{c}	1.80^{a}	1.40^{c}
20%	7.7^{d}	$83.16^{c,d}$	$10.54^{a,b}$	2.40^{b}	2.04^{a}	1.86^{b}
30%	7.6^{d}	80.20^{d}	11.66^{a}	3.45^{a}	2.28^{a}	2.41^{a}
10%+1% DSM	8.2^{c}	$85.25^{b,c}$	$10.32^{a,b}$	1.21^{c}	1.74^{a}	1.48^{c}
Rice grits (Control)	8.7^{a}	89.49^{a}	8.02^{e}	0.18^{d}	1.57^{b}	0.74^{b}
Corn gluten meal, 5%	8.6^{a}	$86.79^{a,b}$	10.33^{d}	$0.27^{c,d}$	1.78^{b}	$0.83^{a,b}$
10%	7.9^{c}	$84.06^{b,c}$	$12.62^{c,d}$	$0.44^{b,c}$	$2.01^{a,b}$	$0.87^{a,b}$
20%	8.2^{b}	77.55^{d}	18.47^{b}	$0.65^{a,b}$	$2.44^{a,b}$	$0.89^{a,b}$
30%	7.5^{d}	71.88^{e}	23.69^{a}	0.79^{a}	2.72^{a}	$0.92^{a,b}$
10%+1% DSM	$8.1^{b,c}$	83.18^{c}	13.55^{c}	$0.38^{c,d}$	$1.94^{a,b}$	0.95^{a}
Rice grits (Control)	8.7^{a}	89.49^{a}	8.02^{e}	0.18^{e}	1.57^{c}	0.74^{c}
Barley mash + Corn gluten meal (1:1), 5%	8.6^{a}	$86.32^{a,b}$	10.33^{d}	0.56^{d}	$1.86^{b,c}$	$0.93^{b,c}$
10%	8.3^{b}	83.78^{d}	12.12^{c}	0.87^{c}	$2.17^{b,c}$	1.06^{b}
20%	8.3^{b}	78.13^{c}	16.82^{b}	1.39^{b}	$2.56^{a,b}$	1.10^{b}
30%	6.0^{d}	72.23^{d}	21.30^{a}	1.98^{a}	3.16^{a}	1.33^{a}
10%+1% DSM	8.0^{c}	83.02^{b}	12.97^{c}	$0.79^{c,d}$	$2.10^{b,c}$	1.12^{b}

*Means of triplicates
**Calculated by difference
Means having the same letter with each property are not significantly different at $p \leq 0.05$.

4- Minerals content

The contents of K, Ca, Mg, Fe, Mn and Zn of the extrudates are presented in Table (4). The results showed that the addition of the tested materials increased the contents of the determine minerals of the extrudates. The main increases were occurred in potassium, magnesium and calcium contents. The greatest increment in potassium and magnesium contents was observed in the extrudates containing corn gluten feed, which rich in these minerals (Schroeder, 1999). Where, it increased from 159.3 and 21.00 mg/ 100 g in base formula to 609.31 and 171.00 mg/ 100 g in extrudates containing 30% corn gluten feed. Barley mash displayed the highest increment in Calcium, Zinc and Ferric contents. The increments in determined minerals were low in the extrudates containing gluten meal because it has low ash content (1.30%) compared with other additives, as shown in Table (1). Adding 1% DSM to the extrudates contain 10% of additives materials caused increase in all determined minerals. The main increment was observed in Calcium content.

Table (4): Effect of adding some food industries by products on some minerals contents* (mg 100 g^{-1}) of rice-based extrudates

Extrudate type		K	Ca	Mg	Fe	Mn	Zn
Rice grits (Control)		159.30^{e}	51.00^{e}	21.00^{f}	5.75^{e}	0.60^{d}	1.08^{e}
Barley mash,	**5%**	187.02^{d}	88.00^{d}	61.61^{e}	6.74^{d}	0.70^{c,d}	1.48^{d}
	10%	197.12^{c}	92.00^{c}	66.30^{d}	8.58^{c}	0.89^{c}	1.65^{d}
	20%	207.73^{b}	94.61^{c}	94.13^{b}	15.28^{b}	1.40^{b}	2.55^{b}
	30%	207.92^{b}	152.49^{a}	110.01^{a}	19.36^{a}	1.88^{a}	2.97^{a}
	10%+1% DSM	228.92^{a}	105.20^{b}	86.19^{c}	8.98^{c}	1.08^{c}	1.86^{c}
Rice grits (Control)		159.30^{f}	51.00^{d}	21.00^{f}	5.75^{a}	0.60^{b}	1.08^{e}
Corn gluten feed,	**5%**	275.03^{e}	70.35^{c}	84.20^{e}	2.94^{d}	0.65^{b}	1.36^{d}
	10%	346.45^{d}	71.51^{c}	100.55^{d}	3.06^{c}	0.69^{a,b}	1.55^{c}
	20%	555.80^{b}	72.98^{c}	156.01^{b}	3.47^{b,c}	0.78^{a,b}	1.86^{a,b}
	30%	609.31^{a}	99.67^{a}	171.00^{a}	3.86^{b}	0.78^{a,b}	1.93^{a}
	10%+1% DSM	364.71^{c}	95.08^{b}	122.88^{c}	3.27^{c}	0.89^{a}	1.70^{b,c}
Rice grits (Control)		159.30^{d}	51.00^{d}	21.00^{e}	5.75^{a}	0.60^{a,b}	1.08^{a}
Corn gluten meal,	**5%**	193.65^{c}	83.24^{c}	22.88^{e}	3.24^{c}	0.49^{b}	0.95^{a}
	10%	203.04^{b}	84.87^{b,c}	28.23^{d}	3.91^{b}	0.59^{a,b}	0.98^{a}
	20%	206.97^{b}	87.15^{b}	35.01^{c}	4.36^{b}	0.68^{a,b}	1.05^{a}
	30%	285.95^{a}	92.29^{a}	43.24^{a}	4.38^{b}	0.76^{a}	1.15^{a}
	10%+1% DSM	208.92^{b}	93.00^{a}	40.26^{b}	4.13^{b}	0.66^{a,b}	1.11^{a}
Rice grits (Control)		159.30^{d}	51.00^{f}	21.00^{e}	5.75^{e}	0.60^{d}	1.08^{d}
Barley mash + Corn gluten meal (1:1),	**5%**	188.18^{c}	80.70^{e}	48.91^{d}	5.03^{f}	0.69^{c}	1.12^{d}
	10%	199.56^{b}	85.11^{d}	55.62^{c}	6.76^{d}	0.69^{c}	1.37^{c}
	20%	202.84^{a,b}	92.69^{c}	57.99^{c}	10.25^{b}	1.08^{a,b}	1.85^{b}
	30%	207.61^{a}	103.94^{a}	75.25^{a}	15.32^{a}	1.28^{a}	2.32^{a}
	10%+1% DSM	203.19^{a,b}	100.00^{b}	69.52^{b}	7.39^{c}	0.88^{b,c}	1.50^{c}

***Calculated on dry basis**

Means having the same letter with each property are not significantly different at $p \leq 0.05$.

5- Sensory properties of produced extrudates

The organoleptic properties remains the final judge of food quality. Thus, the effect of adding tested materials was evaluated through sensory evaluation individually with rice base extrudate.

The results of sensory evaluation of rice extrudates with tested materials are presented in Table (5). The high scores were noticed in taste of extrudate samples, which prepared from rice grits (15.0 degree) and that containing 5% of barley mash either alone (15.0) or as a mixture with gluten meal (16.0), 10% of both corn gluten feed (15.83) and meal (17.0).

Table (5). Effect of adding some food industries by products on the sensory properties of rice-based extrudates

Extrudate type	Taste	Crispness	Odor	Chewiness	Color	Surface characteristics	Pore distribution	Overall acceptability	
Rice grits (Control)	15.00^{a}	15.13^{b}	12.88^{a}	10.50^{a}	6.00^{b}	7.00^{b,c}	7.88^{a}	74.39^{a,b}	Fair
Barley mash, 5%	15.00^{a}	16.6^{a}	14.20^{a}	11.00^{a}	7.20^{a}	7.40^{a,b}	7.20^{a,b}	78.60^{a}	Good
10%	14.57^{a}	15.71^{b}	12.86^{a}	12.29^{a}	6.86^{a}	7.71^{a}	7.71^{a}	77.71^{a,b}	Good
20%	13.00^{a}	9.83^{d}	12.83^{a}	8.67^{b}	6.50^{a,b}	7.50^{a,b}	6.50^{b}	64.83^{c}	Fair
30%	9.33^{b}	4.00^{e}	11.50^{a}	6.67^{c}	3.83^{c}	3.83^{d}	4.17^{c}	43.33^{d}	Poor
10%+1% DSM	13.67^{a}	13.00^{c}	12.67^{a}	11.33^{a}	7.17^{a}	6.50^{c}	7.67^{a}	72.01^{b}	Fair
Rice grits (Control)	15.00^{a}	15.13^{b}	12.88^{a}	10.50^{b}	6.00^{b}	7.00^{d}	7.88^{a}	74.39^{c}	Fair
Corn gluten feed, 5%	14.71^{a}	16.29^{a,b}	12.29^{a}	13.29^{a}	7.29^{a}	8.29^{a,b}	8.14^{a}	80.30^{a,b,c}	Good
10%	15.83^{a}	17.33^{a}	12.33^{a}	13.00^{a}	7.50^{a}	7.83^{b,c}	8.33^{a}	82.15^{a}	Good
20%	15.67^{a}	16.83^{a}	12.00^{a}	12.67^{a}	7.67^{a}	8.33^{a,b}	8.17^{a}	81.34^{a,b}	Good
30%	13.29^{a}	17.57^{a}	11.14^{a}	12.29^{a}	6.43^{b}	7.43^{c,d}	6.86^{b}	75.01^{b,c}	Good
10%+1% DSM	15.29^{a}	17.57^{a}	12.86^{a}	12.86^{a}	7.86^{a}	8.71^{a}	8.57^{a}	83.72^{a}	Good
Rice grits (Control)	15.00^{b}	15.13^{b}	12.88^{a}	10.50^{b}	6.00^{c}	7.00^{c}	7.88^{a}	74.39^{b}	Fair
Corn gluten meal, 5%	17.00^{a}	17.43^{a}	12.57^{a}	13.00^{a}	7.86^{a,b}	7.71^{a,b}	7.86^{a}	84.43^{a}	Good
10%	17.00^{a}	17.29^{a}	13.00^{a}	12.71^{a}	8.00^{a,b}	7.86^{a}	7.57^{a}	83.43^{a}	Good
20%	16.71^{a,b}	17.86^{a}	12.86^{a}	13.00^{a}	7.71^{a}	7.29^{b,c}	7.43^{a}	82.86^{a}	Good
30%	14.67^{b}	17.83^{a}	12.17^{a}	12.17^{a}	7.33^{b}	6.83^{c}	7.33^{a}	78.33^{a,b}	Good
10%+1% DSM	17.29^{a}	17.43^{a}	13.43^{a}	13.43^{a}	8.41^{a}	8.00^{a}	7.86^{a}	85.85^{a}	Excellent
Rice grits (Control)	15.00^{a,b}	15.13^{b,c}	12.88^{a}	10.50^{b}	6.00^{c}	7.00^{b,c}	7.88^{a}	74.39^{b}	Fair
Barley mash + corn gluten meal (1:1), 5%	16.00^{a}	15.71^{a,b}	12.57^{a}	13.14^{a}	7.57^{a,b}	7.57^{a,b}	6.86^{b}	79.42^{a,b}	Good
10%	14.43^{a,b}	16.57^{a,b}	12.57^{a}	12.71^{a}	7.86^{a}	8.14^{a}	8.14^{a}	80.42^{a,b}	Good
20%	13.88^{b,c}	16.88^{a}	12.63^{a}	12.75^{a}	6.88^{b}	7.38^{b,c}	8.00^{a}	78.40^{a,b}	Good
30%	12.25^{c}	13.75^{c}	11.00^{a}	10.75^{b}	5.50^{c}	6.88^{c}	7.75^{a}	67.88^{c}	Fair
10%+1% DSM	14.63^{a,b}	16.75^{a}	13.25^{a}	13.38^{a}	7.63^{a}	8.00^{a}	8.13^{a}	81.77^{a}	Good

Means having the same letter with each property are not significantly different at $p \leq 0.05$.

The mean scores significantly decreased by increasing the ratio of additives materials in its blends. Extrudates containing corn gluten meal had highest taste scores at different ratios compared with other materials. As shown in the same Table, it could be noticed that, the tested materials had no significant effect under all tested levels on the odor of produced extrudates.

The data presented in Table (5) show that adding barley mash alone or as a mixture with corn gluten meal up to 10% increased the crispness, color, surface characteristics and pore distribution scores of the resultant extrudates. By increasing the addition levels from these materials in blends, the mean scores of these properties decreased. Extrudates prepared with corn gluten feed or meal at any level of addition received high crispness scores compared with those for base formula. Adding gluten feed or meal up to 20% enhanced the color, surface characteristics and pore distribution of the resultant extrudates. Many authors reported that, attempts to incorporate high levels of fiber in extruded product often resulted in compact, non-crisp, tough and undesirable texture in extrudates (Anderson *et al.*, 1981 and Hu-L, 1994). Also, Skierkowshi *et al.* (1990) reported that crispness scores were highest in blends containing 13-16% protein content. At values below or above this range of protein, the scores decreased and indicated that the extrudates would not be acceptable to consumers.

Generally, from the data in Table (5), it can observed that, addition of tested materials up to 10% in replacement of rice grits significantly improved almost the tested properties of the product resulting overall acceptability with good grade in comparison with control sample which scores a fair grade (74.39%). By increasing the replacement from 10% to 30%, the calculated scores were decreased, but the final grade still good in the extrudates containing corn gluten feed or meal. But, those containing barley mash either alone or as a mixture with gluten meal the grade decreased to poor (43.33%) and fair (67.88%), respectively.

Finally, it could be concluded from this subjective evaluation that high fiber, high protein extrudates with acceptable quality could be prepared from barley mash alone or as a mixture with gluten meal, corn gluten feed or meal up to 10%. Addition of 1% DSM enhanced the overall acceptability of the extrudates, especially which containing gluten meal (excellent grade).

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الاستفادة من المنتجات الثانوية لبعض الصناعات الغذائية في انتاج مبثوقات الأرز عالية المحتوى من الألياف والبروتين

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استهدفت هذه الدراسة امكانية استخدام ثلاث منتجات ثانوية هي مخلف الشعير المنبت والناتج خلال تصنيع البيرة، الجلوتين فيد Gluten feed والجلوتين ميل Gluten meal الناتجان خلال تصنيع نشا الذرة في انتاج مبثوقات الأرز عالية المحتوى من الألياف والبروتين بهدف تعظيم الاستفادة من هذه المنتجات الثانوية. تميز كل من مخلف الشعير والجلوتين فيد بارتفاع محتواهما من الألياف (١٠,٤١ و ١١,٣٤% علي الترتيب) والرماد (٤,٦٣ و ٦,٤٣% علي الترتيب)، بينما تميز الجلوتين ميل بارتفاع محتواه من البروتين (٦٠,٢٥%). اضيفت هذه المواد منفردة أو مخلوط من مخلف الشعير والجلوتين ميل (١:١)فقط بنسب ٥، ١٠، ٢٠ و ٣٠% لرفع محتوى المبثوقات الناتجة من الالياف والبروتين. تم دراسة تأثير هذه الاضافات علي كل من الخواص الطبيعية والوظيفية (نسبة التمدد، الكثافة، معامل امتصاص الماء، معامل درجة الذوبان في الماء، قوة الكسر، اللون)، التركيب الكيماوي، المحتوي من بعض العناصر المعدنية و أخيرا الخصائص الحسية للمنتج النهائي.

أوضحت النتائج المتحصل عليها أن اضافة مخلف الشعير منفردا أو كمخلوط بنسبة ١:١ مع الجلوتين ميل Gluten meal وكذا الجلوتين فيد Gluten feed أدت الي انخفاض قيم كل من نسبة التمدد، معامل امتصاص الماء، معامل درجة الذوبان في الماء، قوة الكسر وقيم L^* في المنتجات، بينما أزدادت قيم كثافتها. أدت اضافة الجلوتين ميل Gluten meal منفردا الي زيادة في نسب التمدد وقيم b^* للمنتجات. اختلف التركيب الكيماوي ومحتوي المنتجات من بعض العناصر المعدنية تبعا لنوع ونسب المواد المضافة.

أوضح التقييم الحسي امكانية انتاج مبثوقات أرز غنية بالألياف والبروتين ومقبولة حسيا باستخدام المواد المختبرة حتى نسبة اضافة ١٠% فقط.