Utilization of Dehydrated Mushroom Flour in Some Functional Food Products

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ABSTRACT

Fresh oyster mushrooms (*Pleurotus ostreatus*) and its dehydrated flour (DMF) were investigated in terms of chemical and technological utilization to prepare of certain food products such as biscuits, cookies, crackers, buns and pizza. The results showed that DMF could be considered as a good source of essential amino acids, minerals such as K, P, Na and Mg, essential fatty acids such as linoleic acid (C 18:2 w6), inulin and dietary fibre, and can be used as a natural antioxidant. The results also indicated that DMF had a very good values in terms of functional properties and *in-vitro* protein digestibility. The prepared food products contained different concentrations of DMF (2.5 up to 10 %) were highly acceptable by panelists and had no or little significant differences with the control samples.

Key words: Oyster mushroom, dehydrated mushroom flour, chemical composition, functional properties, technological utilization.

INTRODUCTION

The mushroom is the fleshy, spore-bearing fruiting body of a fungus, typically produced above ground on soil or on its food source. The standard for the name "mushroom" is the cultivated white button mushroom, *Agaricus bisporus* , hence the word "mushroom" is most often applied to those fungi (*Basidiomycota*, *Agaricomycetes*) that have a stem (stripe), a cap (pileus), and gills (Lamellae, sing. Lamella) or pores on the underside of the cap. Mushroom describes a variety of gilled fungi, with or without stems, and the term is used even more generally, to describe both the fleshy fruiting bodies of some *Ascomycota* and the woody or leathery fruiting bodies of some *Basidiomycota*, depending upon the context of the word, (Dickinson & Lucas, 1982 ,Bano & Rajarathnam, 1987).

Mushrooms are low-calorie food usually eaten raw or cooked to provide garnish to a meal. Raw dietary mushrooms are a good source of B vitamins, such as riboflavin, niacin and pantothenic acid, and the essential minerals, selenium, copper and potassium. Fat, carbohydrates and calorie content are low, with little amount of vitamin C and sodium (Patrick, 2004). Edible mushrooms are used extensively in cooking, and known as the meat of the vegetable world, in many cuisines notably Chinese, Korean, European and Japanese, (Miles & Chang, 2004, Cheung, 2008). Most mushrooms that are sold in supermarkets have been commercially grown on mushroom farms. Oyster mushrooms are now available at many grocers. In recent years, increasing affluence in developing countries has led to a considerable growth in interest in mushroom cultivation, which is now seen as a potentially important economic activity for small farmers (Cheung, 2008). Mushrooms are usually consumed fresh, dried, pickled, canned or may be used for the supplementation of other foods (Gormely & O`Riordain, 1976).

Recently, many agencies and ministries in Egypt offered small projects to the youth to produce mushrooms in order to provide job opportunities, but the Egyptian customers still are not accustomed to taste, flavour and texture of fresh mushrooms. Moreover, fresh mushroom has low shelf life even if it is stored at refrigerated temperature. Thus, the present work was undertaken to prepare dehydrated mushroom powder (DMF) and utilize it in the preparation of some functional foods such as biscuits, crackers, cookies, buns and pizza.

MATERIALS AND METHODS

Materials:

The fresh oyster mushrooms (*Pleurotus ostreatus*) used in the present study was obtained from Plant Protection Research Station, Plant Pathology Research Institute, Agriculture Research Center, El-Sabahia, Alexandria, Egypt (March, 2012). The general appearance of this type of mushroom is illustrated in Fig. (1).

Fig. 1: The general appearance of fresh oyster mushroom (*Pleurotus ostreatus*)

Wheat flour (72% extraction), powdered sugar, vegetable bakery shortening, corn oil, baking powder, sodium chloride, sodium bicarbonate, ammonium bicarbonate, aniseeds, crude chocolate, egg, milk, green pepper, tomato (fresh or paste), pickled olive, bastrami and the other ingredients mentioned in the present work were purchased from the local market, Alexandria, Egypt.

Technological methods

Preparation of dehydrated mushroom powder

Fresh mushrooms were cleaned, cut into 2mm thickness slices, then spread in a single layer on stainless steel trays and dehydrated at 55°C for 12 hr in a thermostatically controlled hot air oven with air van. The dehydrated slices were ground electrically to pass through 80 mesh sieve to obtain dehydrated mushroom flour (DMF). The obtained flour was packed in air-tight Kilner jar and stored in a refrigerator (4°C) until used.

Preparation of biscuits

Biscuits (aniseed and ammonium) were processed according to the method described by Askar (1991). The effect of adding DMF at 2.5, 5, 7.5, and 10% levels based on the weight of wheat flour was studied. The biscuits formula is as follows:

Ingredients	Amounts (g)	
	Aniseed biscuits	Ammonium biscuits
Wheat flour (72% extraction)	250	250
Sunflower oil	75	-
Shortening	-	100
Powdered sugar	100	100
Egg	Two (whole)	One (whole)
Sodium bicarbonate	0.50	0.50
Ammonium bicarbonate	-	1.25
Baking powder	8.0	4.0
Vanilla	5.0	1.25
Water or Milk	-	25 ml
Sodium chloride	1.0	1.0

All ingredients were mixed in the Hobart dough mixer (Model N-50G, 470rpm, Hz 50, Italy) for 7min. at 470 rpm. The dough was flattened using sheeting roll machine and shaped. Baking was performed at 150°C for 15 min. Biscuits were allowed to cool and stored in polyethylene bags at room temperature (25°C).

Chocolate chip cookies

Chocolate chip cookies were prepared from the following ingredients: 250 g wheat flour (72% extraction), 125 g shortening, 125 g brown sugar, 62.5 g white granulated sugar, 2.5 g vanilla, 1 egg beaten, 2.5 g baking soda, 1 g salt and 125 g chocolate chips. The effect of adding 2.5, 5.0, 7.5 and 10% DMF based on the weight of wheat flour on the cookies quality was studied. The shortening and sugars were creamed, then beaten eggs and vanilla were added. Flour, baking soda, salt, chocolate chips and DMF were combined all together and added to the creamed mixture. The mixture was dropped by teaspoonful onto a cookie sheet, leaving 5 cm between the cookies. The cookies were baked at 180˚ C for 10 to 12 min until golden colour was maintained. The cookies were removed from sheet and left to cool before packaging in polyethylene bags and kept at room temperature (25 °C).

Crackers

Crackers were prepared from the following ingredients: 375 g wheat flour (72% extraction), 20 g shortening, 2 g baking powder, 2g sodium chloride and 125 g skim milk powder. The effect of adding 2 and 5% levels of DMF based on the weight of wheat flour on the crackers quality was studied.

The flour, baking powder, salt and shortening were combined all together in a bowl of a stand-up mixer. With the paddle attachment, the mixture was mixed on low speed until it resembles a coarse meal. The aforementioned mixture was stirred in milk and mixed until mixture forms a soft dough. The dough was wrapped in plastic wrap and chilled for l0 min. Then, it was divided into quarters, turned out onto a lightly floured board, rolled out very thin to a rectangle shape 2 mm thick, cutted into 6 cm squares. The latter was transferred to an ungreased baking sheets, repeated with remainder of the dough, and then baked in preheated oven at 160˚C for 20 min until crisp and golden. The crackers were cooled before packaging in polyethylene bags and kept at room temperature (25°C).

Two-hour buns

Two-hour buns were prepared from the following ingredients: 250 g wheat flour (72% extraction), 16.0 g granulated sugar, 1 egg (whole), 0.5 g salt, 0.35 g fast rising instant yeast and 100 ml water. The effect of adding 2.5, 5.0, 7.5 and 10% levels of DMF based on the weight of wheat flour on two-hour buns quality was studied.

The yeast and flour were mixed in a bowl. The sugar, egg and salt were beated in a large bowl. The water was added and stirred. The flour mixture was added to the liquid and beated until well blended. The remaining flour was added and kneaded and let rise for 15 min. The dough was punched down and let rise again for 15 min and then punched down and formed into buns. The buns were placed on greased baking sheet allowing 5cm between buns and then let rise for 1 hr. The buns were baked in a preheated oven at 180°C for 20 min. The buns were removed and cooled on a rack before packaging in polyethylene bags and kept at room temperature (25°C).

Pizza

Pizza was prepared from the following ingredients: 250g wheat flour, (72% extraction) 7.0 g baking powder, 12.5 g sunflower oil, 125 g skim milk powder, 1 egg (whole), 1 g salt, 35 g shredded mozzarella cheese, 25g diced green pepper, 25g diced tomato, small amount of tomato paste, 35 g diced pickled olive and 35 g sliced pastarami. The effect of adding 2.5, 5.0, 7.5 and 10 % levels of DMF based on the weight of wheat flour on pizza quality was studied. The flour, granulated sugar, baking powder, salt were combined in a bowl. In a separate bowl, milk, oil and egg were whisked together, then poured into the dry ingredients, stirred just until dry ingredients were moistened. The mixture was poured into a well greased pan. Tomatoes, green pepper, olive, pastarami and mozzarella cheese were sprinkled on the top of the batter and baked in a preheated oven at 180˚C for 55 to 60 min.

The previous products (cookies, crackers, two-hour buns and pizza) were prepared according to the procedures mentioned in family favourites (recipes and healthful tips) developed by the Flax Council of Canada.

Chemical methods

Chemical analysis including moisture, crude protein the (N×6.25), crude ether extract, total ash and crude fibre were carried out according to the AOAC (2003) methods unless otherwise stated. All determinations were carried out in triplicates. Carbohydrates were calculated by difference. Minerals (Fe, Cu, Mg, Ca, Mn, Zn, Cd and pb) were measured using Perkin Elmer Atomic Absorption Spectrophotometer (Model 2380, U.K). On the other hand, Na and K were determined using flame photometer, Model PEP7 (U.K). Ascrobic acid was determined using 2, 6- dichlorophenol indophenols dye according to the AOAC (2003). Phenolic substances as % tannic acid were determined by Folin-Denis reagent after extracting with 70% ethanol according to Naczk & Shahidi (1989). Total sugars (reducing and non-reducing) were determined using Lane-Eynon procedure as stated in the AOAC (2003).

The inulin was extracted by hot deionized water according to the method of Van Waes *et al*. (1998). The colourimetric dinitrosalicylic acid (DNSA) method (Plummer, 1978) was used for determining the hydrolyzed inulin as fructose.

The total dietary fibre (TDF) content was determined according to the enzymatic-gravimetric method as described by Prosky *et al*. (1985).

Antioxidant activity was measured by the N, N-Dimethyl-P-Phenylenediamine dihydrochloride (DMPD) according to Fogliano *et al*. (1999).

The total lipids were extracted with chloroform: methanol (2:1, v/v) as outlined by the procedure of Folch *et al*. (1957). Total lipid extract was fractionated into different classes using a TLC technique according to the method of Mangold & Malins (1960) on glass plates (20×20 cm) precoat-

ed with 0.25 mm silica gel, G-60. The developing solvent system used was petroleum ether: diethyl ether: glacial acetic acid (70:30:2, v/v/v). After running, the plate was air dried and the separated spots were visualized by iodine vapour in a glass jar. Lipid classes were identified by their R_F values according to Rahma & Abd El-Aal (1988).

Preparation of fatty acid methyl esters was performed according to the procedure of Radwan (1978) using 1% sulphuric acid in absolute methanol. Gas chromatographic analysis was carried out using ACME model 6100 GC (Young LIN Instrument Co., Korea) fitted with a split/splitless injector and FID detector. Nitrogen was used as a carrier gas with a flow rate of 0.5 ml/min. The components were separated on a 30-m SP-2380 fused-silica capillary column with a 0.25-mm i.d. and 0.2-µm film thickness (Supelco, Bellefonte, PA), the detector temperature was set at 360°C. The injector temperature was set at 220°C and in split mode (split ratio 80:1). The column was initially maintained at 140° C for 5 min, and the temperature was subsequently increased to 240°C at a rate of 4°C /min, (total program time 30 min).

The amino acids were determined according to the method described by Spackman *et al*. (1958) using a Beckman model 119CL amino acid analyzer (U.S.A). Ninhydrin was used as a detective compound. Tryptophan was determined colourimetrically in the alkaline hydrolyzate according to the method described by Blauth *et al*. (1963). Amino acid score (AAS) was calculated from the essential amino acid (EAA) content to the total EAA content in 1 g protein of the sample divided by the same EAA content in the reference FAO/WHO Pattern (1985). From the AAS, the limiting AA in DMF which had the lowest values of AAS could be established (FAO/WHO, 1985).

In vitro protein digestibility of DMF using the proteolytic enzymes pepsin followed by pancreatin was determined according to the method described by Prakash & Prakash (1999). The digestibility was calculated as a percentage of digested protein in relation to analysed true protein content of the sample. Functional properties including water and fat absorptions, foam capacity and stability, flour dispersibility and emulsion stability of DMF were determined according to the methods described by Del Rosario & Flores (1981), Chau & Cheung (1998) and Mora-Escobedo *et al*. (1991).

Sensory evaluation of DMF products:

Colour, taste, odour, texture and overall acceptability of DMF products including biscuits, chocolate chip cookies, crackers, two-hour buns and pizza were assessed using 15 panelists of Food Science and Technology Department, Faculty of Agriculture, Alexandria University. The panelists were asked to score the above attributes according to a standared hedonic rating scale from 9 (like extremely) to 1 (dislike extremely) according to Kramer & Twigg (1973).

Statistical analysis:

The data of chemical composition, functional and organoleptic properties were subjected to analysis of variance using Duncan`s multiple range test with SAS system (Steel & Torrie, 1980).

RESULTS AND DISCUSSION

Chemical composition of fresh and dehydrated oyster mushrooms

The moisture content of fresh oyster mushrooms and its dehydrated flour (DMF) was 91.77 and 4.49%, respectively (Table 1). In general, the moisture content of mushrooms ranged from 85 to 95%. However, it must be noted that the moisture content of mushrooms is affected by the time of cropping, watering conditions during cultivation, post harvest period, temperature and relative humidity during growth (Bano & Rajarathnam, 1988, Zakhary *et al*., 1983, Abdel-Hameed, 2005).

The crude protein content of fresh oyster mushrooms and its dehydrated flour (DMF) was 36.25 and 13.77 %, respectively (Table 1). The crude protein content of edible mushrooms is usually high, but varies greatly and is affected by factors such as species and stage of development (Longvah & Deosthale, 1998). The crude protein content (% dry weight) of some common edible mushrooms varied between 15.2% to 34.7% (Manzi *et al*., 1999, Diez & Alvarez, 2001, Baker, 2002, Abdel-Hameed, 2005).

As stated in Table (1), fresh oyster mushrooms generally have a low crude ether extract, being 3.78% on dry weight basis, while DMF had 1.70% (Table 1). The lipid content in edible mushrooms varied between 2.09 to 6.34 (%DW) (Longvah & Deosthale, 1998, Mau *et al*., 2001, Mattila *et al*., 2002, Yang *et al*., 2002, Abdel-Hameed, 2005).

The data in Table (1) shows that the ash content of fresh mushrooms and DMF was 9.93 and 9.36%,

Table 1: Chemical composition of fresh oyster mushrooms and its dehydrated flour

Constituent+	Fresh oyster mushrooms	Dehydrated mushroom flour
	Dwb*	Dwb*
Moisture (%)	91.77±0.73	4.49 ±0.07
Crude protein (%)	36.25±0.07	13.77±0.42
Crude ether extract (%)	3.78±0.06	1.70±0.04
Total ash (%)	9.93±0.27	9.36±0.07
Crude fibre (%)	9.05±0.17	8.05±0.31
N-Free extract**(%)	40.99±0.62	67.12±0.76
Energy value Kcal/100g	377.18±2.65	371.04±2.55
Total sugars (%)	18.54±0.33	7.99±0.14
Reducing	9.49±0.26	4.72±0.06
Non reducing	9.05±0.21	3.26±0.02
Total dietary fibre (%)	5.37±0.26	7.88±0.06
Inulin (%)	10.77±0.46	3.21±0.13
Ascorbic acid (mg/g)	1.66±0.07	0.85±0.03
Phenolic substances (Mg/g as tannic acid)	58.73±0.36	7.35±0.02
Antioxidant activity (%)	49	52

+ Mean of three replicates ± SD * Dry weight basis
** Calculated by difference

respectively. The ash content (%DW) of some edible mushrooms ranged between 5.27 to 9.35% (Zakhary *et al*., 1983, Manzi *et al*., 1999, Mau *et al*., 2001, Baker, 2002, Abdel-Hameed, 2005).

The fresh mushrooms contained 40.99% N-free extract, while DMF had 67.21% N-. free extract. Further, the crude fibre content of both fresh mushrooms and DMF were 9.05 and 8.05%, respectively (Table 1). The obtained data agreed well with those reported by Zakhary *et al*., 1983, Yang *et al*., 2001, Abdel-Hakem, 2002, Baker, 2002, Mattila *et al*., 2002, Abdel-Hameed, 2005.

The energy values calculated and expressed as Kcal/100g sample were 377.18 and 371.04, for fresh oyster mushrooms and DMF respectively (Table 1). The energy content of edible mushrooms is generally low which allows them to be used in low-energy diets. It has been reported that the energy content in edible mushrooms varied between 250 and 427 Kcal/100g (Sethi & Anand, 1984, Aletor, 1995, Manzi *et al*., 2001, Abdel-Hameed, 2005).

The data in Table (1) show that fresh oyster mushrooms and DMF contained considerable amounts of total sugars, being 18.54 and 7.99% on dry weight basis, respectively, approximately, 50% of the total sugars were reducing sugars. The results obtained here agreed well with those reported by Abdel-Hameed (2005). It has been reported that edible oyster mushrooms are believed to contain a low level of total soluble sugars and a high level of oligosaccharides. The profiles of soluble sugars differ across species. (Zakhary *et al*., 1983, Bano & Rajarachnam, 1988, Mau *et al*., 1997, Abdel-Hameed, 2005).

The results presented in Table (1) show that the total dietary fibre contents of fresh oyster mushrooms and its dehydrated powder were 5.37 and 7.88%, respectively. In general, mushrooms are a good source of dietary fibre with 100 g of fresh mushrooms providing between 10 and 40% of the recommended dietary intake of fibre (Manzi *et al*., 2001). Also, it has been reported that there is a large variation in the total dietary fibre content of edible mushrooms, which depends on their morphological form and species (Dies & Alvarez, 2001). The dietary fibres decrease the risk of diverticular disease, play an essential role in the physiology of the gastrointestinal tract and modify the absorption of nutrients in the small bowel. Also, dietary fibres accelerate the gut transit time, affect stool composition and quantity, and encourage the growth of the colonic microflora. Further, they release the detoxicating enzymes, antioxidants and carcinogen inactivating compounds (Praznik *et al*., 2002, Aldoori *et al*., 1998, Trepel, 2004).

Oyster mushrooms and its dehydrated powder have considerable amounts of inulin being, 10.77 and 3.21% on dry weight basis, respectively. It has been reported that inulin has a dietary health benefits for humans. It reduces blood glucose, triacylgycerols, LDL-cholesterol, improves calcium absorption and inhibits the growth of various kinds of cancer (Lamers *et al*., 2003). Also, it forms a perfect nutrient medium for bifedobacteria cells in an alimentary tract (Ewa *et al*., 2002). Also, it is important for preparing diabetic food due to it`s ability to reduce the required amount of inulin for glucose metabolism (Vandorpe, 1991, de Gennaro *et al*., 2000).

The results in Table (1) show that oyster mushrooms and DMF contained very low levels of phenolic compounds and vitamin C. It has been reported that the variation in vitamin C content of mushrooms is wide ranging from 17 to 144 mg/100 g DW (Manzi *et al*., 1999, Mau *et al*., 2001).

The data in Table (1) show that fresh oyster mushrooms and its dehydrated powder have a relatively high percentage of antioxidant activity being 49 and 52%, respectively. These results confirmed the possibility of using fresh oyster mushrooms and its dehydrated powder as an antioxidant source. The antioxidant activity of fresh oyster mushrooms and DMF are quite similar to that of nectarine, peach, plum, tomatoes oregon caneberries, table beets, green beans and artichoke (Takeoka *et al*., 2001, Gil *et al*., 2002, Wada & Ou, 2002, Jiratanan & Liu, 2004, Bekhet & Sharara, 2012).

Mineral content of DMF

Dehydrated mushroom flour is a good source of minerals containing macro elements such as potassium, phosphorus, magnesium and sodium (Table 2), and micro elements such as calcium, zinc, iron, copper and manganese. Very low levels of lead and cadmium were also present in DMF. The results obtained here agreed well with those reported by Maggioni *et al*., 1968, Zakhary *et al*., 1983, Pecora *et al*., 1987, Verma *et al*., 1987, Shah *et al*., 1997, Abdel-Hameed, 2005 and Ouzouni *et al*., 2007. Mushrooms are known to accumulate heavy metals, but the concentrations of these elements are generally assumed to be species dependent, with substrate composition also being an important factor (Svoboda *et al*., 2002, 2006).

Table 2: Mineral content of DMF

Element	Mg/100g*
K	3700±16400
P	940±6.210
Mg	110±9.270
Na	340±5.160
Ca	13.50±1.140
Zn	6.95±0.623
Fe	8.95±0.715
Cu	2.27±0.231
Mn	1.31±0.072
Cd	0.04±٠,٠٢١
Pb	0.02±0.014

*Results are mean of three replicates ± SD on dry weight basis

Amino acid composition of DMF

The results in Table (3) indicated that glutamic acid (12.55), aspartic acid (8.38), alanine (6.90), lysine (6.29), valine (5.67) and leucine (5.67) were the predominant amino acids in DMF. Small amounts of the other amino acids listed in Table (3) were also found in DMF. As indicated from Table (3), the total amount of essential amino acids in DMF was 38.75 g/100 g protein. The obtained results agreed well with those reported by Maggioni *et al*., (1968), Sethi & Anand, (1984), Ogawa *et al*., (1987), Alofe, (1991), Danell & Eaker, (1992), Abdel-Hakem, (2002), and Abdel-Hameed, (2005). The essential amino acid profile revealed that the proteins of DMF are deficient in sulphur-containing amino acids including methionine as compared with FAO / WHO requirement patterns (Table 3). The first limiting amino acid was leucine. It has been reported that lysine, leucine, isoleucine, and tryptophan are the limiting amino acids in some edible mushroom proteins (Cheung, 1997, Manzi *et al*., 1999, Diez & Alvarez, 2001, Abdel-Hameed, 2005).

Table 3: Amino acid composition and chemical score of DMF

Amino acids (g/100g protein)*	DMF	FAO/WHO Pattern**	Chemical score***
Aspartic acid	8.38±2.0		
Threonine	4.15±0.15	3.40	122.06
Serine	4.85±0.25		
Glutamic acid	12.55±0.05		
Proline	4.30±0.12		
Glycine	3.63±0.10		
Alanine	6.90±0.15		
Cystine	1.09±0.12		
Methionine	1.39±0.15	2.50	99.20
Cystine+Methionine	2.48±0.20		
Valine	5.67±0.15	3.50	162.00
Isoleucine	4.76±0.30	2.80	170.00
Leucine	5.67±0.32	6.60	85.91
Tyrosine	3.45±0.20		
Phenylalanine	3.09±0.17		
Tyrosine+Phenylalanine	6.54±0.25	6.30	103.81
Tryptophan	1.35±0.12	1.10	122.73
Histidine	1.84±0.25	1.90	96.84
Lysine	6.29±0.20	5.80	108.45
Arginine	5.55±0.17		
Total EAA	38.75	33.90	

* mean of three replicates ± SD.
** Pattern for 2-5 years old child
*** g of EFA in 100 g protein of the sample divided by the g of the same EAA in 100 g protein of the FAO/ WHO standard pattern × 100.
\+ The first limiting amino acid.

In-vitro protein digestibility and functional properties of DMF

The *in-vitro* protein digestibility of DMF is shown in Table (4). The obtained results show that the digestibility value was 84.67%. This figure is similar to those of legumes but lower than those of protein from animal sources (Diez & Alvarez. 2001). The results obtained here agreed well with those reported by Abdel-Hameed (2005) who found that the *in-vitro* protein digestibility of dried mushroom powder varied between 84.4 and 84.94%.

The data in Table (4) also show that the water absorption value was 3.85 g/g sample. It has been reported that the water absorption value of wheat flour was only 0.75 g/g which is much lower than that of DMF. The data in the same Table indicated that DMF had 1.77 g/g sample of oil absorption capacity. This value is in accordance with that obtained by Abdel-Hameed (2005) who found that oil absorption capacity of dried mushroom powder varied between 1.51 to 2.03 g/g sample. Both water absorption and oil absorption are very important in relation to dough handling. The values obtained here indicated a good ability of DMF to adsorb water and bind oil which is an advantage of the flour for preparing several baked products like biscuits, cookies, crackers and pizza.

Foam capacity is useful in food systems that require aeration for textural and/ or leavening purposes. The foam capacity of DMF was about 65.43%. This high value is mainly due to the high protein content of DMF. Abdel-Hameed (2005) reported that oven/sun-dried mushroom powder had higher foaming capacity value (65%) than those of either wheat flour (60%) or sun-dried mushroom powder (52%). The results in Table (4) show that DMF had high value of emulsion stability (57.69%). It has been reported that the emulsion stability is based on its molecular structure and its ionic tensile between the polar and non-polar phases (Belitz & Grosch, 1999). The value obtained here agreed well with those reported by Abdel-Hameed (2005) who found that the partial replacement of wheat flour with dried mushroom powder improved the foam stability of the obtained blends. The flour dispersibility is defined as the volume of the suspended particles after stirring and resting for 30 min (Mora-Escobedo *et al*., 1991). The obtained results showed that 52.3% of DMF was still suspended after 30 min of resting time. The results indicated that the dispersibility of DMF was significantly high which may be due to its high protein content on dry weight basis.

Table 4: *In vitro* protein digestibility and functional properties of DMF

Parameters	Value *
In-vitro- protein digestibility (%)	84.67±0.38
Water absorption g/g sample	3.85±0.56
Oil absorption g/g sample	1.77±0.35
Foam capacity (%)	65.43±0.75
Emulsion stability (%)	57.69±0.45
Dispersibility (cm^3)	5.23±0.05

* Mean of three replicates ± SD

Fatty acid composition and lipid classes of DMF

As it can be seen from Table (5), the levels of polyunsaturated fatty acids in DMF are high constituting more than 79% of the total fatty acids, of which linoleic (69.18%), palmitic (14,18%) and oleic (9.77%) acids are the most significant. Linolenic acid level is generally low (0.23%). It has been reported that despite its small quantity, linolenic acid is strongly related to flavour in certain mushrooms, as it is the precursor to 1-octen-3-ol, or the alcohol of fungi, and this is the principal aromatic compound in most mushrooms (Maga, 1981). The results obtained here are in a good agreement with those reported by Maggioni *et al*., (1968), Cheung, (1997), Longvah & Deosthale, (1998), Diez & Alvarez, (2001) and Yang *et al*., (2002).

Table 5: Fatty acid composition of DMF

Fatty acid	%*
Myristic acid C14:0	1.47±0.14
Palmitic acid C 16:0	14.18±0.20
Palmitoleic acid C 16:1	0.45±0.0.4
Stearic acid C 18:0	1.550.06±
Oleic acid C 18:1	9.770.03±
Linoleic acid C 18:2	69.180.01±
Linolenic acid C 18:3	0.230.05±
Arachidic acid C 20:3	2.610.08±
- others	0.560.07±
TSFA (S)**	19.81
TUFA (U)***	79.63
U/S ratio	4.02

* Expressed as mean of three replicates ± SD
** Total saturated fatty acids
*** Total unsaturated fatty acids

The results of the fractionation of the total lipid classes of DMF are shown in Fig. (2). The total lipids of DMF consisted mainly of 7 fractions of acylglycerols and non- acylglycerol components in addition to the polar lipid class located on the base line. Triacylglycerols were found to be the major fraction of DMF lipids. On the other hand, the other classes can be arranged, based on their R_F, as follows:- Monoacylglycerols,1,2 and 2, 3 diacylglycerols, sterols, 1,3 diacylglycerols, free fatty acids, triacylglycerols, hydrocarbons and sterolesters based on the front line.

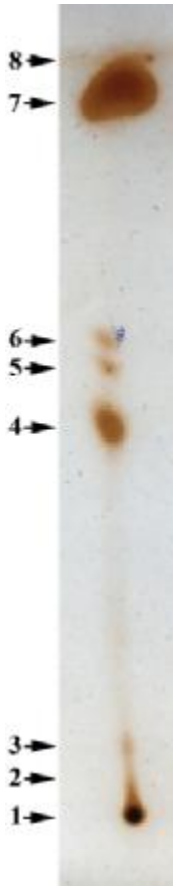

Fig. 2: Thin layer chromatogram of total lipids of DMF

1: Polar lipids
2: Monoacylglycerols
3: 1,2 and 2,3 diacylglycerols
4: sterols
5: 1,3 diacylglycerols
6: Free fatty acids
7: Triacylglycerols
8: Hydrocarbons and sterolesters

Sensory evaluation of some products containing DMF

The general appearance of some food products containing DMF is presented in Fig. (3).

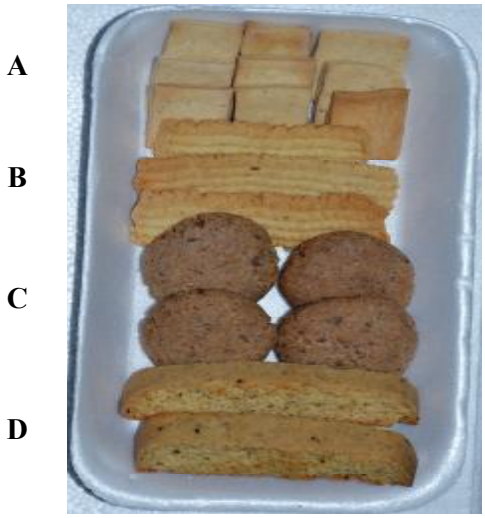

Fig. 3: The general appearance of some food products containing DMF

A- Crackers
B- Ammonium biscuits
C- Chocolate chip cookies
D- Aniseed biscuits

Aniseed and ammonium biscuits:

The organoleptic properties of aniseed and ammonium biscuits containing DMF are given in Table (6).

The organoleptic attributes of aniseed and ammonium biscuits containing DMF including colour, taste, odour, texture and overall acceptability were over the numerical value of 7 (like moderately) except the odour of ammonium biscuits containing 7.5 and 10% DMF. These results indicated that all the characters studied were very well accepted by the panelists. Also, the results indicated that no significant differences were noticed in the organoleptic attributes in the two different types of biscuits even those containing the different percentage of DMF.

Chocolate chip cookies

In the light of the obtained data, it was obvious that panelists accepted this product and the overall acceptability was described by the panelists as like very much except the last treatment which contains 10% DMF but still accepted by the panelists. The data also revealed that no significant differences were noticed in the organoleptic characters between the control sample and those contained up to 7.5% DMF.

Crackers

The organoleptic properties of crackers containing DMF are given in Table (8)

Except the texture of crackers containing 2.5% and 5.0 DMF, no significant differences were noticed in the organoleptic attributes of crackers (control sample) or those containing 2.5 and 5 % DMF. The three samples of crackers were still well accepted by the panelists because all the attributes were over the numerical value of 7.

Two-hour buns

According to the obtained data in Table (9), the organoleptic attributes of the two-hour buns decreased with increasing the amount of DMF. Slight and moderate significant differences were noticed between the control sample and those containing the differents concentrations of DMF. In spite of these findings, all the treatments were still accepted by the panelists even those containing the higher percentage of DMF.

Pizza

The results of the organoleptic properties of Pizza containing DMF revealed, slight significant

Table 6: Organoleptic evaluation of aniseed and ammonium biscuits containing DMF

Treatments	Characters*									
	colour		taste		odour		texture		Overall acceptability	
	A	B	A	B	A	B	A	B	A	B
Control	8.53[a]	7.66[a]	8.00[a]	7.60[a]	8.26[a]	7.40[a]	8.00[a]	7.93[a]	8.20[a]	7.40[a]
2.5%	8.00[a]	7.73[a]	8.20[a]	7.66[a]	7.80[a]	7.20[a]	7.00[a]	8.26[a]	8.06[a]	7.73[a]
5.0%	8.26[a]	7.86[a]	8.33[a]	7.93[a]	8.13[a]	7.20[a]	8.00[a]	7.93[a]	8.33[a]	7.53[a]
7.5%	8.13[a]	7.53[a]	8.40[a]	7.33[a]	8.33[a]	6.86[a]	7.93[a]	7.60[a]	8.20[a]	7.20[a]
10.0%	8.00[a]	7.50[a]	8.26[a]	7.20[a]	7.93[a]	6.73[a]	7.73[a]	7.33[a]	7.93[a]	7.20[a]
LSD 0.05	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

* Means in a column not sharing the same letter are significantly different at $P \leq 0.05$.
A: Aniseed biscuits B: Ammonium biscuits

Table 7: Organoleptic evaluation of chocolate chip cookies containing DMF

Treatments	Characters*				
	Colour	Taste	Odour	Texture	Overall acceptability
Control	8.13[a]	8.33[a]	8.33[a]	8.46[a]	8.60[a]
2.5%	8.20[a]	8.46[a]	8.53[a]	8.66[a]	8.73[a]
5.0%	8.20[a]	8.06[ab]	8.20[a]	8.33[a]	8.13[a]
7.5%	8.13[a]	7.26[b]	7.80[a]	8.06[a]	8.06[a]
10.0%	7.13[b]	7.53[b]	8.06[a]	7.33[b]	7.33[b]
LSD 0.05	0.71	0.65	N.S.	0.59	0.64

* Means in a column not sharing the same letter are significantly different at $P \leq 0.05$.

Table 8: Organoleptic evaluation of crackers containing DMF

Treatments	Characters*				
	Colour	Taste	Odour	Texture	Overall acceptability
Control	7.73[a]	7.40[a]	7.60[a]	8.13[a]	7.60[a]
2.5%	7.66[a]	7.80[a]	7.73[a]	7.46[b]	7.73[a]
5.0%	7.33[a]	7.53[a]	7.53[a]	7.20[b]	7.33[a]
LSD 0.05	N.S.	N.S.	N.S.	0.31	N.S.

* Means in a column not sharing the same letter are significantly different at $P \leq 0.05$.

Table 9: Organoleptic evaluation of two-hour buns containing DMF

Treatments	Characters*				
	Colour	Taste	Odour	Texture	Overall acceptability
Control	8.86[a]	8.60[a]	8.60[a]	8.53[a]	8.93[a]
2.5%	8.06[b]	7.86[b]	8.46[a]	8.53[a]	8.53[a]
5.0%	7.06[c]	7.53[b]	8.00[b]	8.00[a]	7.46[c]
7.5%	6.66[cd]	6.86[c]	7.40[c]	7.20[b]	6.93[d]
10.0%	6.40[b]	6.86[c]	6.80[d]	7.00[b]	6.40[e]
LSD 0.05	0.51	0.33	0.36	0.49	0.38

* Means in a column not sharing the same letter are significantly different at $P \leq 0.05$

Table 10: Organoleptic evaluation of pizza containing DMF

Treatments	Characters*				
	Colour	Taste	Odour	Texture	Overall acceptability
Control	9. 00[a]	9. 00[a]	9. 00[a]	9.00[a]	9. 00[a]
2.5%	9.00[a]	8.46[b]	8.40[b]	8.53[ab]	8.60[b]
5.0%	8.86[a]	8.13[b]	8.33[b]	8.53[ab]	8.40[bc]
7.5%	8.06[b]	7.93[b]	8.00[b]	8.13[b]	7.86[c]
10.0%	8.06[b]	7.66[b]	7.93[b]	7.86[b]	7.80[c]
LSD 0.05	0.54	0.61	0.65	0.61	0.57

* Means in a column not sharing the same letter are significantly different at $P \leq 0.05$.

differences between the control sample and those containing the different concentrations of DMF (Table 10). In spite of these findings, pizza containing the different concentrations of DMF are still very accepted by the panelists, because all the characters including colour, taste, odour, texture and overall acceptability were over the numerical value of 7 (like moderately).

From the aforementioned results, it can be concluded that the addition of DMF can improve the nutritional value with regard to protein content, some essential amino acids, minerals especially K, P, Na and Mg, some essential fatty acids such as linoleic acid and certain functional components such as inulin, dietary fibre and antioxidants.

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الاستفادة من مسحوق عيش الغراب المجفف فى بعض المنتجات الغذائية الوظيفية

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تم تحليل عيش الغراب المحارى الطازج ودقيقه المجفف من حيث الصفات الكيماوية والإستفادة التكنولوجية فى تحضير بعض المنتجات الغذائية مثل البسكويت، والكوكيز، والمقرمشات والبيتزا. وأوضحت النتائج أن دقيق عيش الغراب المحارى المجفف يمكن اعتباره مصدراً جيداً للأحماض الأمينية الأساسية وبعض المعادن مثل البوتاسيوم، الفوسفور، الصوديوم والماغنسيوم، وبعض الأحماض الدهنية الأساسية مثل حامض اللينوليك والذى ينتمى إلى العائلة اوميجا ٦ وكذلك الإينولين والألياف الغذائية. كما أثبتت الدراسة أنه يمكن استخدام دقيق عيش الغراب المحارى كمضاد طبيعى للأكسدة. كذلك أثبتت الدراسة أن الخصائص الوظيفية ومعامل الهضمية المعملية لبروتينات دقيق عيش الغراب المحارى المجفف ذات قيمة جيدة جدا. وقد لاقت جميع المنتجات الغذائية المحضرة التى احتوت على تركيزات مختلفة من دقيق عيش الغراب المحارى (٢,٥ – ١٠ ٪) قبولاً عالياً لدى المحكمين لدرجة أنه لم يكن في مقدور المحكمين التفرقة معنوياً بين تلك المنتجات والعينات الكونترول المناظرة.