International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(6): 1199-1202

Received: 07-09-2017
Accepted: 09-10-2017

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Functional properties of food commodities (wheat, kidney bean, cowpea, turnip, cauliflower) flours

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Abstract
The wheat (*Triticum*), kidney bean (*Phaseolus vulgaris*), cowpea (*Vigna unguiculata*), turnip (*Brassica rapa subsp. rapa)* and cauliflower (*Brassica oleracea var. botrytis*) were obtained from the open market sorted, washed, dried at 70^0C in a cabinet dryer and milled. The functional properties (swelling capacity, water absorption capacity, oil absorption capacity, emulsion activity and stability, foam capacity and stability, least gelation concentration, gelatinization temperature and bulk density) of flours were evaluated. wheat flour obtain highest score for OAC, kidney bean flour in FC and FS; cowpea flour with SC; Turnip flour in ES, GT and LGC Cauliflower flour WAC, EA, LGC and bulk density.

Keywords: Functional property, swelling capacity, water absorption capacity, oil absorption capacity, emulsion activity, emulsion stability, foam capacity and stability, least gelation concentration, gelatinization temperature, bulk density

Introduction
Flour is a substance, generally a powder, made by grinding raw grains or roots and used to make many different foods. Cereal grains contain 60 to 70% starch and are excellent energy rich food for human. Doctors recommended cereals as the first food to be added to infant diets and a healthy diet for adults should have most of its calories in the form of complex carbohydrates such as cereals grain starch. Cereals and millets form the staple food of diets in about 75% of the countries of the world (Khader, 2001) [14].
Cereals are an excellent source of vitamin and minerals including fat soluble vitamin E, which is an essential antioxidant. The cereal grains are an easy protein source as required by Recommended Daily Allowance (RDA) but unfortunately they are lack in the essential amino acid lysine and therefore they must not be used as the sole source of dietary protein (Khatkar, 2005) [15]. Carbohydrates are present in the form of digestible starches and sugars. The operations of milling generally remove much of the indigestible fibre and fat from the grains when they are to be consumed for human food (Potter and Hotchkiss, 1996) [23]. Cereals do not contain vitamin A or vitamin C (Rama and Venkat, 1995) [25]. Wheat flour approximately consists of 72% carbohydrates, 8 to 13% protein, 12 to 13% moisture, 2.5% sugar and 1.5% fat, 1.0% soluble protein and 0.5% minerals salts (Oberoi *et al*., 2007) [21]. Wheat flour is main ingredients used in the manufacturing of noodles and characteristics of wheat used for milling are very important. Soft wheat is used in cakes, pastries, cookies, crackers and oriental noodles where as hard wheat is used in breads. Cowpea is loaded with various types of nutrients. It is rich in fiber, protein, iron, potassium, low in fat and calories. The kidney bean is an important food crop, and a major source of protein throughout the world. Used in a variety of traditional dishes, kidney beans are usually eaten well cooked. Cauliflower is an excellent source of vitamin C, vitamin K, folate, pantothenic acid, and vitamin B6. It is a very good source of choline, dietary fiber, omega-3 fatty acids, manganese, phosphorus, and biotin. Additionally, it is a good source of vitamin B1, B2, and B3, the minerals potassium and magnesium, and protein. Turnip is a great source of minerals, antioxidants, and dietary fiber. It is also a low-calorie vegetable. Turnip greens also contain B vitamins (riboflavin, folates, pyridoxine pantothenic acid, and thiamin), calcium, copper, manganese, and iron, as well as phytonutrients like quercetin, myricetin, kaempferol, and hydroxycinnamic acid, which help lower your risk of oxidative stress.

Functional properties are the fundamental physico-chemical properties that reflect the complex interaction between the composition, structure, molecular conformation and physico-chemical properties of food components together with the nature of environment in which these are associated and measured (Kinsella, 1976 [16]; Kaur and Singh, 2006 [12]; Siddiq *et al*., 2009 [28]. Functional characteristics are required to evaluate and possibly help to predict how new proteins, fat, fibre and carbohydrates may behave in specific systems as well as demonstrate whether or not such protein can be used to stimulate or replace conventional protein (Mattil, 1971 [18]; Kaur and Singh, 2006 [12]; Siddiq *et al*., 2009) [28]. A functional property of food is determined by physical, chemical, and/or organoleptic properties of a food. Example of functional properties may include solubility, absorption, water retention, frothing ability, elasticity and absorptive capacity for fat and foreign particulars. Typical functional properties include emulsification, hydration (water binding), viscosity, foaming, solubility, gelation, cohesion and adhesion. The objective of this study involves the collection of data on the functional properties of flours. This provides the useful information to industry purpose and other alike on the subsequent incorporation of the different flours along with wheat flour to produce natural, cheap and acceptable functional foods.

Material and Methods

The experiments were conducted in Bakery Lab and Food Analysis Laboratory in the Department of Agricultural Engineering, S.V.P. University of Agriculture and Technology, Meerut India. Raw materials *viz*., wheat flour (maida or refined flour), kidney bean flour, cowpea flour, turnip flour, cauliflower flour, chemicals, etc. were procured from the local market for the present study. The functional properties of flours were analyzed i.e., swelling capacity (SC, ml), water absorption capacity (WAC,%), oil absorption capacity (OAC,%), emulsion activity (EA,%), emulsion stability (ES,%), foam capacity (FC,%), foam stability (FS,%), gelatinization temperature (GT, °C), least gelatinization concentration (LGC,%) and bulk density (g/cc).

The swelling capacity was determined by the method described by Okaka and Potter (1977) [22]. 100 ml graduated cylinder was filled with the sample to 10 ml mark. The distilled water was added to give a total volume of 50 ml. The top of the graduated cylinder was tightly covered and mixed by inverting the cylinder. The suspension was inverted again after 2 min and left to stand for a further 8 min and the volume occupied by the sample was taken after the 8th min.

The water absorption capacity of the flours was determine by the method of Sosulski *et al*. (1976) [29]. One gram of sample mixed with 10 ml distilled water and allow to stand at ambient temperature (30 ± 2 °C) for 30 min, the centrifuged for 30 min at 3000 rpm or 2000 × g. Oil absorption was examined as percent oil bound per gram flour. The oil absorption capacity was determine by the method of Sosulski *et al*. (1976) [29]. One gram of sample mixed with 10 ml soybean oil (Sp. Gr. 0.9092) and allow to stand at ambient temperature (30 ± 2°C) for 30 min, and centrifuged for 30 min at 3000 rpm or 2000 × g. Water absorption was examined as percent water bound per gram flour.

The emulsion activity and stability by Yasumatsu *et al*. (1972) [30] described and followed as the emulsion (1 g sample, 10 ml distilled water and 10 ml soybean oil) was prepared in calibrated centrifuged tube. The emulsion was centrifuged at 2000 × g for 5 min. The ratio of the height of emulsion layer to the total height of the mixture was calculated as emulsion activity in percentage. The emulsion stability was estimated after heating the emulsion contained in calibrated centrifuged tube at 80°C for 30 min in a water-bath, cooling for 15 min under running tap water and centrifuging at 2000 × g for 15 min. The emulsion stability expressed as percentage was calculated as the ratio of the height of emulsified layer to the total height of the mixture.

The foam capacity (FC) and foam stability (FS) by Narayana and Narasinga (1982) [19] were determined as described with slight modification. The 1.0 g flour sample was added to 50 ml distilled water at 30 ± 2°C in a graduated cylinder. The suspension was mixed and shaken for 5 min to foam. The volume of foam at 30 sec after whipping was expressed as foam capacity using the formula:

$$\text{Foam capacity (\%)} = \frac{\text{Volume of foam AW} - \text{Volume of foam BW}}{\text{Volume of foam BW}} \times 100$$

Where, AW = after whipping, BW = before whipping.

The volume of foam was recorded one hour after whipping to determine foam stability as per percent of initial foam volume. The least gelation concentration (LGC) was evaluated using of Coffman and Garcia (1977) [8] with modification. The flour dispersions of 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, and 30% (w/v) prepared in 5 ml distilled water was heated at 90°C for 1 h in water bath. The contents were cooled under tap water and kept for 2 h at 10 ± 2°C.

The least gelation concentration was determined as that concentration when the sample from inverted tube did not slip. Gelatinization temperature was determined by Shinde (2001) [27]. 1 g flour sample was weighed accurately in triplicate and transferred to 20 ml screw capped tubes. 10 ml of water was added to each sample. The samples were heated slowly in a water bath until they formed a solid gel. At complete gel formation, the respective temperature was measured and taken as gelatinization temperature.

The volume of 100 g of the flour was measured in a measuring cylinder (250 ml) after tapping the cylinder on a wooden plank until no visible decrease in volume was noticed, and based on the weight and volume, the apparent (bulk) density was calculated (Jones *et al*., 2000) [11].

The data obtained from the various experiments were recorded during the study and were subjected to statistical analysis as per method of "Analysis of variance" by Factorial Randomized Block Design (factorial R.B.D.). The significant difference between the means was tested against the critical difference at 5% level of significance (Gomez and Gomez, 1984) [9]. OPSTAT software was used to analyze the recorded data.

Results and Discussion

In the present research, various types of functional property of five different flours were analysed. Swelling capacity is an indication of the water absorption index of the granules during heating (Loos *et al*., 1981) [17]. The highest swelling capacity was found in cowpea flour (31.333ml) followed by kidneybean flour (31.000ml) turnip flour (30.167ml) cauliflower flour (25.333ml) and lowest in wheat flour (17.167ml) (Table 1).

The water and oil binding capacity of food protein depend upon the intrinsic factors like amino acid composition, protein conformation and surface polarity or hydrophobicity (Chandra and Samsher, 2013) [7]. WAC was found highest in cauliflower flour (372.416%) followed by turnip flour

(291.303%), kidneybean (186.503%), cowpea flour (142.832%) and wheat flour (141.916%). The lower water absorption capacity of wheat flour could be attributed due to the presence of lower amount of hydrophilic constituents in wheat (Akubor and Badifu, 2001) [6]. WAC is a critical function of protein in various food products like soups, dough and baked products (Adeyeye and Aye, 1998) [3]. In general, WAC is an important processing parameter and has implication for viscosity. It is also essential in bulking and consistency of products as well as in baking application (Niba *et al*., 2001) [20]. The highest WAC in cauliflower flour could be attributed due to hygroscopicity.

The oil absorption capacity of flour is important as it improves the mouthfeel and retains the flavour (Igbabul *et al*., 2015) [10]. The highest value of oac was found for wheat flour 153.122% followed by kidneybean flour 98.991%, turnip flour 96.901%, cauliflower flour 51.734% and cowpea flour 48.822%.

Highest emulsion activity (50.984%) was found in cauliflower flour followed by turnip flour (46.108%), wheat flour (43.141%), cowpea flour (25.213%) and kidneybean flour (21.749%). Difference in the EA of protein may be related to their solubility exhibited the lowest emulsifying activity and highest emulsion stability. Hydrophobicity of protein has been attributed to influence their emulsifying properties (Kaushal *et al*., 2012) [13]. Similar trends were reported by (Chandra and Samsher, 2013) [7].

The value of emulsion stability was found highest in turnip flour (42.460%) followed by cauliflower flour (40.346%), wheat flour (38.078%), kidneybean flour (19.140%) and lowest in cowpea flour (6.949%). These properties are influenced by many factors among which are solubility, pH and concentration. The capacity of protein to enhance the formation and stabilization of emulsions is important for many applications in food products like cake, coffee whiteners and frozen desserts. In these products, varying emulsifying and stabilizing capacity are required because of their various compositions and processes (Adebowale *et al*., 2005)[1]. Increasing emulsion activity (EA), emulsion stability (ES) and fat binding during processing are primary functional properties of protein in such foods as comminuted meat products, salad dressing, frozen desserts and mayonnaise (Chandra and Samsher, 2013) [7]. Emulsion stability is important phenomena for thick consistency in biscuit baking (Prajapati *et al*., 2015) [24].

The highest foam capacity was observed for kidney bean flour (22.755%) followed by cowpea flour (17.627%), wheat flour (11.734%), cauliflower flour (8.653%) and turnip flour (7.371%). Flours are capable of producing foams due to surface active proteins (Adebowale & Lawal, 2003) [2].

The value of foam stability was found highest in kidney bean flour (8.974%) followed by cowpea flour (6.089%), cauliflower flour (2.884%), wheat flour (1.962%) and turnip flour (1.920%). Protein in the dispersion may cause a lowering of the surface tension at the water air interface, thus always been due to protein which forms a continuous cohesive film around the air bubbles in the foam (Kaushal *et al*., 2012) [13].

The temperature at which gelatinization of starch take place is known as the gelatinization temperature (Sahay and Singh, 1996) [26]. The highest gelatinization temperature was observed for turnip flour 86.08 ºC followed by cauliflower flour 80.66 ºC, cowpea flour 67.41 ºC, kidneybean flour 65.83 ºC and wheat flour 60.75 ºC. As per literature, the turnip had lowest amount of carbohydrate in form of starch. It observed highest value of gelatinization temperature.

The value of least gelatinization concentration was found highest in turnip and cauliflower flour 12% followed by kidneybean flour 10%, wheat and cowpea flour 8%. (Chandra and Samsher, 2013) [7] reported that the flour which was higher in starch content look lowest temperature for gelatinization.

The highest bulk density was observed in cauliflower flour 0.973g/cc followed by turnip flour 0.969g/cc, cowpea flour 0.845g/cc, kidneybean flour 0.785g/cc and wheat flour 0.731g/cc. bulk density depends on the particle size and initial moisture content of flours. The high bulk density of flour suggests their suitability for use in food preparations. On contrast, low bulk density would be an advantage in the formulation of complementary foods (Akpata and Akubor, 1999) [4].

Table 1: Functional properties of different flours

Functional Properties	Treatments					
	Wheat Flour	**Kidney Bean Flour**	**Cowpea Flour**	**Turnip Flour**	**Cauliflower Flour**	**CD 0.05**
Swelling Capacity (Ml)	17.167 ±0.76	31.000 ±6.56	31.333 ±4.16	30.167 ±4.75	25.333 ±5.01	7.478
Water Absorption Capacity (%)	141.916 ±4.82	186.503 ±1.20	142.832 ±2.88	291.303 ±13.70	372.416 ±10.41	14.847
Oil Absorption Capacity (%)	153.122 ±3.05	98.991 ±1.49	48.822 ±1.62	96.901 ±1.42	51.734 ±3.59	4.581
Emulsion Activity (%)	43.141 ±2.25	21.749 ±1.70	25.213 ±1.37	46.108 ±2.18	50.948 ±2.06	3.486
Emulsion Stability (%)	38.078 ±0.87	19.140 ±1.67	6.949 ±1.46	42.460 ±2.12	40.346 ±0.79	3.060
Foam Capacity (%)	11.734 ±1.64	22.755 ±1.47	17.627 ±2.42	7.371 ±1.47	8.653 ±0.96	3.208
Foam Stability (%)	1.962 ±0.07	8.974 ±1.11	6.089 ±1.47	1.92 ±0.07	2.884 ±0.96	1.499
Gelatinization Temperature (^{0}c)	60.75 ±1.75	65.83 ±1.04	67.41 ±0.38	86.08 ±2.32	80.66 ±1.29	2.966
Least Gelatinization Conc. (%)	8	10	8	12	12	-
Bulk Density (G/Cc)	0.731 ±0.02	0.785 ±0.01	0.845 ±0.01	0.969 ±0.01	0.973 ±0.02	0.022

Conclusion

The food property is characterized of the structure, quality, nutritional value and /or acceptability of a food product. These functional properties may prove very beneficial in the application of flours in various food formulations and can also improve the flour blend property. Wheat flour is good in oil absorption capacity and gelatinization temperature, kidney bean in foam capacity and foam stability, cowpea flour was found good in swelling capacity, turnip flour was found good in emulsion stability and least gelatinization concentration and cauliflower flour found good in water absorption capacity and emulsion activity and bulk density.

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