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Assessment of functional properties of different flours

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The present research was carried out to study the functional properties of different flours, that is, wheat flour, rice flour, green gram flour and potato flour. 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) and moisture content of flours were evaluated. Wheat flour had highest moisture content and emulsion activity while rice flour observed lowest value for foam capacity. Potato flour had highest value of swelling capacity, water absorption capacity, oil absorption capacity and emulsion stability. Highest bulk density observed for rice flour while foam capacity; least gelatinization concentration and gelatinization temperature for green gram flour compared to others. Green gram flour and potato flour have good functional properties which enhance the nutritional quality of the value added products which processed by addition of them.

Key words: Functional property, swelling capacity, water absorption capacity, oil absorption capacity, emulsion activity and stability, foam capacity and stability, least gelation concentration, gelatinization temperature.

INTRODUCTION

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).

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 lack the essential amino acid lysine and therefore they must not be used as the sole source of dietary protein (Khatkar, 2005). Cereal grains contain about 58 to 72% carbohydrates, 8 to 13% protein, 2 to 5% fat, and 2 to 11% indigestible fibre. They also contain 300 to 350 kcal/100 g of the grain. 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). Cereals do not contain vitamin A or vitamin C (Rama and Venkat, 1995).

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). 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.

Rice flour (also rice powder) is a form of flour made from finely milled rice. It is distinct from rice starch, which is usually produced by steeping rice in lye. Rice flour may be made from either white rice or brown rice. Rice flour is

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a particularly good substitute for wheat flour, which causes irritation in the digestive systems of those who are gluten-intolerant. Rice flour is a staple in India, Japan, Southeast Asia and Thailand. It is mainly used for making noodles, desserts and sweets. It is also an excellent thickener for sauces, custards and gravies. Rice flour is also used as a thickening agent in recipes that are refrigerated or frozen since it inhibits liquid separation.

Mung bean flour is starchy gluten free fine grain flour that has many uses in the Asian countries such as China, India, Pakistan, Japan, etc. This fine gluten-free flour is used in combination with other flours or on its own, depending on the end product. Because of its starch content, it holds the foods well. This flour rich in minerals such as calcium, magnesium, and phosphorous is used in sweets and savories as per one's taste.

Potato can be processed into a variety of products. Chips and French fries are the most common processed products of potato. Potato flour can be prepared and used to partially replace wheat 'maida' (refined flour) in the preparation of biscuits and other bakery products. Potato biscuits prepared with refined wheat flour : potato flour (1:1) are crisp and tasty with highly acceptable sensory acceptable. Using potato starch, custard powder was prepared in two colours and two flavours. The yellow colour custard powder with vanilla flavour and pink colour custard powder with strawberry flavour are good to taste and are comparable to the commercially available corn custard powder.

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; Kaur and Singh, 2006; Siddiq et al., 2009). 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; Kaur and Singh, 2006; Siddiq et al., 2009).

The food property is characterized of the structure, quality, nutritional value and /or acceptability of a food product. 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 provide 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.

MATERIALS AND METHODS

The experiments were conducted in Bakery Lab and Food Analysis Laboratory in the Department of Agricultural Engineering and Food Technology, S.V.P. University of Agriculture and Technology, Meerut India. Raw materials *viz*., wheat flour (maida or refined flour), rice flour, mung flour, potato, chemicals, etc. were procured from the local market for the present study. Initial moisture content of samples was determined by hot air oven drying method as recommended by AOAC (2000). The functional properties of flours were analyzed that is, swelling capacity (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). 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 8^{th} min. The water absorption capacity of the flours was determine by the method of Sosulski et al. (1976). 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). One gram of sample mixed with 10 ml soybean oil (Sp. Gravity 0.9092) and allow to stand at ambient temperature (30 ± 2°C) for 30 min, the centrifuged for 30 min at 300 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) 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) 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:

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

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) 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.

Table 1. Functional properties of different flours.

Functional properties	Types of flours				$CD_{0.05}$
	Wheat flour	Rice flour	Green gram flour	Potato flour	
Moisture, %	13.284 ± 1.467	11.222±0.432	8.052±0.194	9.604±0.423	0.831
SC, %	17.60±1.85	15.20±0.84	19.80±1.48	42.90±2.07	1.854
WAC, %	140±12.25	192±10.95	196±11.40	752±21.68	22.103
OAC, %	146±08.94	124±21.91	160±14.14	168±10.95	19.360
EA, %	43.88±4.119	41.48±1.842	41.17±1.021	39.05±4.984	3.627
ES, %	38.38±4.785	37.31±5.407	37.95±2.362	41.92±1.824	4.870
FC, %	12.922±5.027	3.52±0.894	24.23±3.669	6.84±1.033	3.260
FS, %	1.94±0.048	0.98±0.000	14.07±2.691	2.488±0.935	1.898
LGC, %	8	6	18	6	-
GT, °C	59.22±0.148	57.58±0.164	62.36±0.114	59.72±0.084	0.288
BD, g/cc	0.762±0.006	0.914±0.012	0.776±0.005	0.720±0.009	0.010

SC, Swelling capacity; WAC, Water absorption capacity; OAC, Oil absorption capacity; EA, Emulsion activity; ES, Emulsion stability; FC, Foam capacity; FS, Foam stability; GT, Gelatinization temperature; LGC, Least gelatinization concentration; BD, Bulk density.

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). 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).

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). STATPAC (OPSTAT) software was used to analyze the recorded data.

RESULTS AND DISCUSSION

In the present study of research, various type of functional properties of flours were analyzed. The highest value of moisture content was observed for wheat flour (13.28%) and the lowest for green gram flour (8.05%) shown in Table 1.

The value of swelling capacity was found highest for potato flour (42.90 ml) followed by green gram (19.80 ml), wheat flour (17.60 ml) and lowest for rice flour (15.20 ml). The swelling capacity of flours depends on size of particles, types of variety and types of processing methods or unit operations. As per literature, the flour of parboiled rice has more swelling capacity as compared to raw rice.

The WAC was observed highest in potato flour (752%) followed by green gram flour (196%), rice flour (192%) and wheat flour (140%). Water absorption capacity or characteristics represent the ability of a product to associate with water under conditions where water is limited (Singh, 2001). The highest WAC of potato flour could be attributed to the presence of higher amount of carbohydrates (starch) and fibre in this flour. Water absorption capacity is a critical function of protein in various food products like soups, dough and baked products (Adeyeye and Aye, 1998).

The highest value of OAC was observed for potato flour (168%) followed by green gram flour (160 %), wheat flour (146%) and rice flour (124%). 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. Potato flour having highest OAC could be therefore being better to rice flour as flavor retainer. The ability of the proteins of these flours to bind with oil makes it useful in food system where optimum oil absorption is desired. This makes flour to have potential functional uses in foods such as sausage production. The OAC also makes the flour suitable in facilitating enhancement in flavor and mouth feel when used in food preparation. Due to these properties, the protein probably could be used as functional ingredient in foods such as whipped toppings, sausages, chiffon dessert, angel and sponge cakes etc.

Highest EA (43.88%) was observed in wheat flour followed by rice flour (41.48%), green gram flour (41.17%) and potato flour (39.05%). 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). 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).

Highest ES was observed for potato flour (41.92%), wheat flour (38.38%), green gram flour (37.95%) and lowest for rice flour (37.31%). 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.

The highest foam capacity was observed for green gram flour (24.23%) followed by W100 (12.92%), potato flour (6.84%) and lowest for rice flour (3.52%). The highest foam stability was observed for green gram flour (14.07%) followed by potato flour (2.488%), and wheat flour (1.94%) and lowest for rice flour (0.98%). Green gram flour obtained the highest foam capacity due to higher protein content. 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).Green gram flour formed a gel at a significantly higher concentration (18 g/ 100 ml). Pulse/legume flours contain high protein and starch content and the gelation capacity of flours is influenced by physical competition for water between protein gelation and starch gelatinization (Kaushal et al., 2012). Rice and potato flour formed gel quickly at very lowest concentration (6 g/100 ml) while green gram formed gel at highest concentration (18 g/100 ml).

The temperature at which gelatinization of starch take place is known as the gelatinization temperature (Sahay and Singh, 1996). The highest GT was observed for green gram flour (62.36°C) and lowest for rice flour (57.58°C) as individual flour. The study revealed that the flour which was higher in starch content took lowest temperature for gelatinization. As rice and potato flour took less time for gelatinization due to higher starch while green gram flour took more time due to lower starch content. The highest bulk density was observed for rice flour (0.914 g/cc) and lowest for potato flour (0.720 g/cc). The present study revealed that 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).

Conclusions

In the recent research, there is a trend to use novel sources of protein, fat, vitamins, minerals for bakery products to decrease the proportion of wheat flour by using locally available cheap and nutritional sources. Green gram flour and potato flour have good functional properties which enhance the nutritional quality of the value added products which processed by addition of them.

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