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Physico-chemical and functional properties of different flours used for preparation of cookies

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Abstract
The physic-chemical and functional properties of wheat flour, semolina, barley flour, corn flour, bajra flour, ragi flour, mung bean flour, carrot powder, guava powder and oat flour were investigated. The functional properties (water absorption capacity, swelling capacity, oil absorption capacity, emulsion activity, emulsion stability, foam capacity, foam stability and bulk density) and physic-chemical properties (moisture content, protein, fat, crude fibre, ash, pH, carbohydrate, energy and optical density) were evaluated. The pH of flours ranged from 4.07 to 6.81. The carbohydrate of flours ranged from 70.54 to 74.61%. The energy of flours ranged from 358.51 to 383.57 Kcal. The WAC of the flours varied from 90.33 to 379%. Study revalue Guava powder showed lowest oil absorption capacity as compared to other flours. In another case, barley flour reported highest score of oil absorption capacity due to depend on protein content of barley four.

Keywords: Water absorption capacity, swelling capacity, oil absorption capacity, emulsion activity, moisture content, protein and crude fibre

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 (Khader, 2001) [19]. Cereals are an excellent source of vitamin and minerals including fat soluble vitamin E, which is an essential antioxidant (Chandra and Samsher, 2013) [7].
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) [20, 18, 38]. 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) [24, 18, 38].
Wheat (*Triticum aestivum* L.) is an important raw material in many countries. The grain is composed of a nutritious inner part, the starchy endosperm, and surrounded by multiple histological layers that are typically separated as one from the endosperm through roller milling, yielding millers bran (Hemdane *et al*., 2016a) [13]. Bran fraction constitutes approximately 11% of total milling by-products and only 10% of bran is used as fiber supplement in breakfast cereals and bakeries while the remaining 90% is sold as animal feed at an extremely low price (Hossain *et al*., 2013) [14]. Semolina particle size is a key factor in cookies making. Fine semolina gives a higher yield upon milling and is preferred by the cookies industry since it shows a high hydration rate and permits a homogeneous hydration, thus facilitating the mixing process (Mondelli, 2008) [26]. Fine semolina is also particularly suitable for modern high speed extrusion processes, characterized by limited dough residence time, and confers to cookies a highly homogeneous colour with a higher yellow colour saturation than coarse semolina (Milatovic and Mondelli, 1991) [25].
Oats (*Avena sativa* L.) ranks around sixth in the world cereals production statistics following wheat, maize, rice, barley and sorghum. They are good source of proteins, fibre and minerals. The amount of oats used for human consumption has increased progressively, the fact health effects of oats benefits mainly on the total dietary fibre and B- glucan content (Mushtaq *et al*., 2014) [27].

Barley (BR) (*Hordeum vulgare*) grains are an excellent source of many nutrients. The major fibre constituent in BR is b glucan which is associated with plasma cholesterol reduction and lowering of glycaemic index (Skrbic and Cvejanov, 2011) [39]. The composition of BR grain is as follows (% on dry weight): Starch 60–64%, proteins 8–15%, lipids 2–3%, minerals (ash) 3–5%, dietary fibre 15.6% and b-glucan content around 3.6–6.1% (Macgregor, 1993) [22]. Barley flour is rich in dietary fiber (beta glucan), which helps to lower cholesterol by binding to bile acids and removing them from the body via the faeces, magnesium and selenium (Kumar *et al*., 2021) [21].

Maize (*Zea mays*) has the highest world-wide production of all grain crops. Maize is a major source of starch. Maize flour is a major ingredient in home cooking and in many industrialized food products. Maize is also a major source of cooking oil (corn oil) and of maize gluten (FAO Statistics Division, 2009; Thompson *et al*., 2010) [11, 41]. Maize germ is a rich source of lysine and exceeds the double amount of lysine in wheat flour (Tsen *et al*., 1974) [42].

Corn is richer in oil than any other cereal crop except oat and millet (Enwere, 1998) [10]. Corn is also richer in vitamin A and ash contents, particularly the yellow varieties (Akpapunam and Darbe, 1994) [3]. It is high in calorie, carbohydrate, protein, potassium, sodium, chlorine and sulphur (Enwere, 1998) [10]. When considered as a whole, protein of corn is still low in lysine, very low in tryptophan but reasonably fair in sulphur containing amino acids such as methionine and cysteine (Adebayo and Emmanuel, 2001) [1]. Corn is exclusively high in leucine and aromatic amino acids, phenylalanine and tyrosine (Akpapunam and Darbe, 1994) [3].

Pearl mill*et al.*so known as bajara is one of the important millet grown in tropical and semi-arid region of the world 32% production of pearl millet found in India (Nambiar *et al*., 2011) [29]. The amino acid composition has significant effect on the nutritional quality of protein. The amino acid profile of pearl millet is better than that of sorghum and maize and is comparable to wheat, barley, and rice (Rai *et al*., 2008) [35].

Mung beans (*Vigna radiata)* are legumes that are small, ovoid in shape and green in colour. They are also known as green gram or golden gram (Chavalvut and Somchai, 1990) [8]. The protein content of mung bean is about 24% (Masood *et al*., 2010) [23]. Mung bean is rich in vitamin A, B1, B2, niacin vitamin C, potassium, phosphorus and calcium (Prabhavat, 1990) [34].

Carrot (Daucus carota L.) is one of the important nutritious root vegetables grown throughout the world. It is an excellent source of phytonutrients such as phenolics, polyacetylenes and carotenoids (Babic *et al*., 1993; Hansen *et al*., 2003; Block, 1994) [5, 12, 6]. The main physiological function of carotenoids is as precursor of vitamin A (Nocolle *et al*., 2003) [31]. Carotenoids are potent antioxidants present in carrots which help to neutralize the effect of free radicals. Reports have showed that they have inhibitory mutagenesis activity thus, contributing to decrease risk of some cancers (Dias, 2012) [9].

Guava (*Psidium guajava* L.) is one of the major fruit crop broadly cultivated in India after mango, banana and citrus. It belongs to the *Myrtaceae* family and is a native of tropical and sub-tropical regions. It is considered as one of the best and cheapest fruit of India because of its excellent digestive and nutritive value, pleasant flavour, high palatability and availability in abundance at affordable prices. Guava, a biennial crop, is a rich in pectin, fiber, folic acid, minerals like potassium, copper, manganese, calcium, iron, phosphorus and vitamins like ascorbic acid, thiamine, riboflavin, nicotinic acid and vitamin A. The fruit being rich in many phytochemicals resulted in increasing its demand in food industry because of its therapeutic value (Kalra and Tandon, 1984) [17].

Materials and Methods

Raw materials *viz*., wheat flour, semolina, barley flour, corn flour, bajra flour, ragi flour and packaging materials (Aluminium Foil) were purchased from the local market of Meerut. Mung bean flour, carrot powder, guava powder and oat flours were prepared in Product Development Laboratory, College of Post Harvest Technology and Food Processing, SVP University of Agriculture and Technology, Modipuram, Meerut analysis of flours were done in NCML, Gurugram.

Development of mung bean flour

Mung bean was procured from the market and after cleaning, the damaged and infested grains were removed manually. The cleaned mung bean was soaked overnight to destroy the anti-nutritional factor by soaking. Soaked mung bean was dried up to 8-10 hours in tray dryer upto 5-6% moisture content and grind by grinder. Mung bean flour was also sieved.

Development of oat flour

Oat was procured from the market and after cleaning, the damaged and infested grains were removed manually. The cleaned oat was soaked overnight to destroy the anti-nutritional factor by soaking. Soaked oat was dried up to 10-12 hours in tray dryer upto very low moisture content and grind by domestic *Atta chakki* into-three pass. Oat flour was also sieved.

Development of carrot powder

Initially, the tray dryer was run for 30 minutes to stabilize the desired temperature. The carrot was washed, peeling and sliced. Before drying in tray dryer, carrot was blanched in hot water at 95℃ for 4-5 min. and then dried in tray dryer at 60℃ for 10-12 hours. The corresponding moisture content of the sample was computed through mass balance. At the end of drying, samples were cooled in desiccators at room temperature and grind to make carrot powder.

Development of guava powder

Initially, the tray dryer was run for 30 minutes to stabilize the desired temperature. The guava was washed, sliced and deseeded. Before drying in tray dryer, guava was blanched in hot water at 95℃ for 4-5 min. and then dried in tray dryer at 60℃ for 10-12 hours. The corresponding moisture content of the sample was computed through mass balance. At the end of drying, samples were cooled in desiccators at room temperature and grind to make guava powder.

Analysis of functional properties

In present studies were also carried out to evaluate the functional properties *viz*.: swelling capacity, water absorption capacity, oil absorption capacity, emulsion activity, emulsion stability, foam capacity, foam stability and bulk density of composite flours.

The swelling capacity was determined by the method described by Okaka and Potter (1977) [32]. The water absorption capacity of the flours was determined by the method of Sosulski *et al*., (1976) [40]. Oil absorption was examined as percent oil bound per gram flour. The oil absorption capacity was determined by the method of Sosulski *et al*., (1976) [40]. The emulsion activity and stability by Yasumatsu *et al*., (1972) [43] 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 foam capacity (FC) and foam stability (FS) by Narayana and Narasinga (1982) [30] were determined as described with slight modification. 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) [16].

Physico-chemical analysis

Moisture content of the sample was determined by standard air oven method (Ranganna, 2001) [36]. Fat content was determined by (Nagi *et al*., 2007) [28]. The crude protein was estimated by micro Kjeldahl Method (AOAC, 1990) [4]. The ash Content was estimated by (Ranganna, 2001) [36]. Crude fiber estimated by employing standard method of analysis (AOAC, 1990) [4]. The samples of cookies will be crushed with equal quantity of distilled water and the pH will determined using digital pH meter after calibration with standard buffers of 4 and 7 (Ranganna, 2010) [37]. Carbohydrate content of the flour samples was determined by using the formula described by (James, 1995) [15]. The total energy content (kcal) of the sample was obtained by (Pearson, 1976) [33]. The Optical density is the measurement of light that is absorbed by any material when a beam of light falls on it. According to the Bear's law the intensity of a beam of monochromatic light decreases exponentially as concentration of absorbing substance increases. Mathematically, O.D. of medium is given by following formula.

$$\text{Optical Density} = log\frac{I_o}{I_i}$$

Where,

I_o = Intensity of the incident light

I_i = Intensity of light transmitted through the medium.

Optical density of a sample would be determined by using method as recommended by Ranganna (2001) [36].

Results and Discussion

Functional properties of flours

The functional properties *viz.*: swelling capacity, water absorption capacity, oil absorption capacity, emulsion activity, emulsion stability, foam capacity, foam stability and bulk density of individual flours were analysed and presented in Table 1 and Fig 1.

The WAC of the flour varied from 90.33 to 379% among all the types of individual flours. Water absorption capacity was observed highest in carrot powder (379%) and lowest in semolina (90.33%). The water absorption capacity of different flours were noted as wheat flour (113%), oat flour (121%), barley flour (132.15%), corn flour (169.67%), bajra flour (119%), ragi flour (121%), mung bean flour (77.33%) and guava powder (97%). Texture and structure of semolina also affected the water absorption capacity due to higher mechanical strength (hardness) among the other flour. The semolina showed lowest water absorption capacity as compared to others. In another case, carrot powder had highest value of WAC due to very fine particles of carrot powder.

The swelling capacity of the flour varied from 12 to 63 ml among all the types of individual flours. Swelling capacity was observed highest in guava powder (63 ml) and lowest in oat flour (12 ml). The swelling capacity of different flours were noted as wheat flour (32ml), semolina (20ml), barley flour (24ml), corn flour (22ml), bajra flour (14ml), ragi flour (20ml), mung bean flour (30ml) and carrot powder (58ml). Texture and structure of oat flour also affected the swelling capacity due to higher among the other flour. The oat flour showed lowest swelling capacity as compared to other flours. In another case, guava powder had highest value of swelling capacity due to very fine particles and pH of guava powder.

The oil absorption capacity of the flours varied from 72 to 126% among all the types of individual flours. Oil absorption capacity was observed highest in barley flour (126%) and lowest in guava powder (72%). The oil absorption capacity of different flours was noted as wheat flour (108%), semolina (96%), oat flour (102%), corn flour (101%), bajra flour (102%), ragi flour (97%), mung bean flour (96%) and carrot powder (80%). Texture and structure of guava powder also affected the oil absorption capacity among the other flour. The guava powder showed lowest oil absorption capacity as compared to other flours. In another case, barley flour had highest value of oil absorption capacity due to depend on protein content of the barley four.

The emulsion activity of the flour varied from 4.30 to 45.07% among all the types of individual flours. Emulsion activity was observed highest in mung bean flour (45.07%) and lowest in corn flour (4.30%). The emulsion activity of different flours was noted as wheat flour (7.72%), semolina (8.70%), oat flour (21.88%), barley flour (6.57%), bajra flour (10.72%), ragi flour (7.14%), carrot powder (7.20%) and guava powder (5.43%). Texture and structure of corn flour also affected the emulsion activity among the other flour. The corn flour showed lowest emulsion activity as compared to other flours. In another case, mung bean flour had highest value of emulsion activity due to depend on protein content and carbohydrate of the mung bean flour.

The emulsion stability of the flour observed from 4.76 to 50.40% among all the types of individual flours. Emulsion stability was observed highest in bajra flour (50.40%) and lowest in carrot powder (4.76%). The emulsion stability of different flours were noted as wheat flour (5.56%), semolina (6.88%), oat flour (15.63%), barley flour (5.60%), corn flour (30.60%), ragi flour (13.06%), mung bean flour (45.56%) and guava powder (7.20%). Texture and structure of carrot flour also affected the emulsion stability among the other flour. The carrot powder showed lowest emulsion stability as compared to other flours. In another case, bajra flour had highest value of emulsion stability due to depend on carbohydrate of the bajra flour.

The foam capacity of the flour observed from 6 to 50% among all the types of individual flours. Foam capacity was observed highest in mung bean flour (50%) and lowest in semolina (6%). The foam capacity of different flours was noted as wheat flour (26%), oat flour (14%), barley flour (10%), corn flour (8%), bajra flour (14%), ragi flour (14%) and carrot powder (22%). Texture and structure of semolina also affected the foam capacity due to higher mechanical strength (hardness) among the other flour. The semolina showed lowest foam capacity as compared to other flours. In another case, mung bean flour had highest value of foam capacity due to depend on protein content and carbohydrate of the mung bean flour.

The foam stability of the flour observed from 4 to 14% among all the types of individual flours. Foam stability was observed highest mung bean flour (14%) and lowest in ragi flour (4%). The foam stability of different flours were noted as wheat flour (8%), oat flour (10%), barley flour (6%), bajra flour (6%) and carrot powder (5%). Texture and structure of ragi flour also affected the foam stability among the other flour. The ragi flour showed lowest foam capacity as compared to other flours. In another case, mung bean flour had highest value of foam stability due to depend on protein content and carbohydrate of the mung bean flour.

The bulk density of the flour observed from 0.602 to 1.042g/cc among all the types of individual flours. Bulk density was observed highest in carrot powder (1.042g/cc) and lowest in oat flour (0.602g/cc). The bulk density of different flours was noted as wheat flour (0.769g/cc), semolina (0.833g/cc), barley flour (0.676g/cc), corn flour (0.769g/cc), bajra flour (0.746g/cc), ragi flour (0.806g/cc), mung bean flour (0.893g/cc) and guava powder (0.980g/cc). Particles size and structure of oat flour also affected the bulk density among the other flour. The semolina showed lowest bulk density as compared to others. In another case, carrot powder had highest value of bulk density due to fine particles of carrot powder.

Table 1: Functional properties of individual flours

Flour	Water absorption capacity (%)	Swelling capacity (ml)	Oil absorption capacity (%)	Emulsion activity (%)	Emulsion stability (%)	Foam capacity (%)	Foam stability (%)	Bulk density (g/cc)
Wheat Flour	113.00±5.650	32.00±1.000	108.00±5.400	7.72±0.386	5.56±0.278	26.00±1.300	8.00±0.400	0.769±0.038
Semolina	90.33±3.646	20.00±0.800	96.00±3.840	8.70±0.348	6.88±0.275	6.00±0.240	0.00±0.000	0.833±0.033
Oat Flour	121.00±7.260	12.50±0.800	102.00±6.120	21.88±0.313	15.63±0.938	14.00±0.840	10.00±0.600	0.602±0.036
Barley Flour	132.15±2.783	24.00±1.000	126.00±4.080	6.57±0.526	5.60±0.448	10.00±0.800	6.00±0.480	0.676±0.054
Corn Flour	169.67±5.090	22.00±1.000	101.00±3.030	4.30±0.129	30.60±0.918	8.00±0.240	0.00±0.000	0.769±0.023
Bajra Flour	119.00±4.760	14.00±0.600	102.00±4.080	10.72±0.429	50.40±2.016	14.00±0.560	6.00±0.240	0.746±0.030
Ragi Flour	121.00±6.050	20.00±1.000	97.00±4.850	7.14±0.357	13.06±0.653	14.00±0.700	4.00±0.200	0.806±0.040
Mung Bean Flour	77.33±4.130	30.00±1.800	96.00±5.760	45.07±1.296	45.56±0.734	50.00±2.000	14.00±0.840	0.893±0.054
Carrot Powder	379.00±6.530	58.00±3.000	80.00±5.600	7.20±0.504	4.76±0.333	22.00±1.540	5.00±0.350	1.042±0.073
Guava Powder	97.00±7.760	63.00±2.000	72.00±5.760	5.43±0.434	7.20±0.576	0.00±0.000	0.00±0.000	0.980±0.078

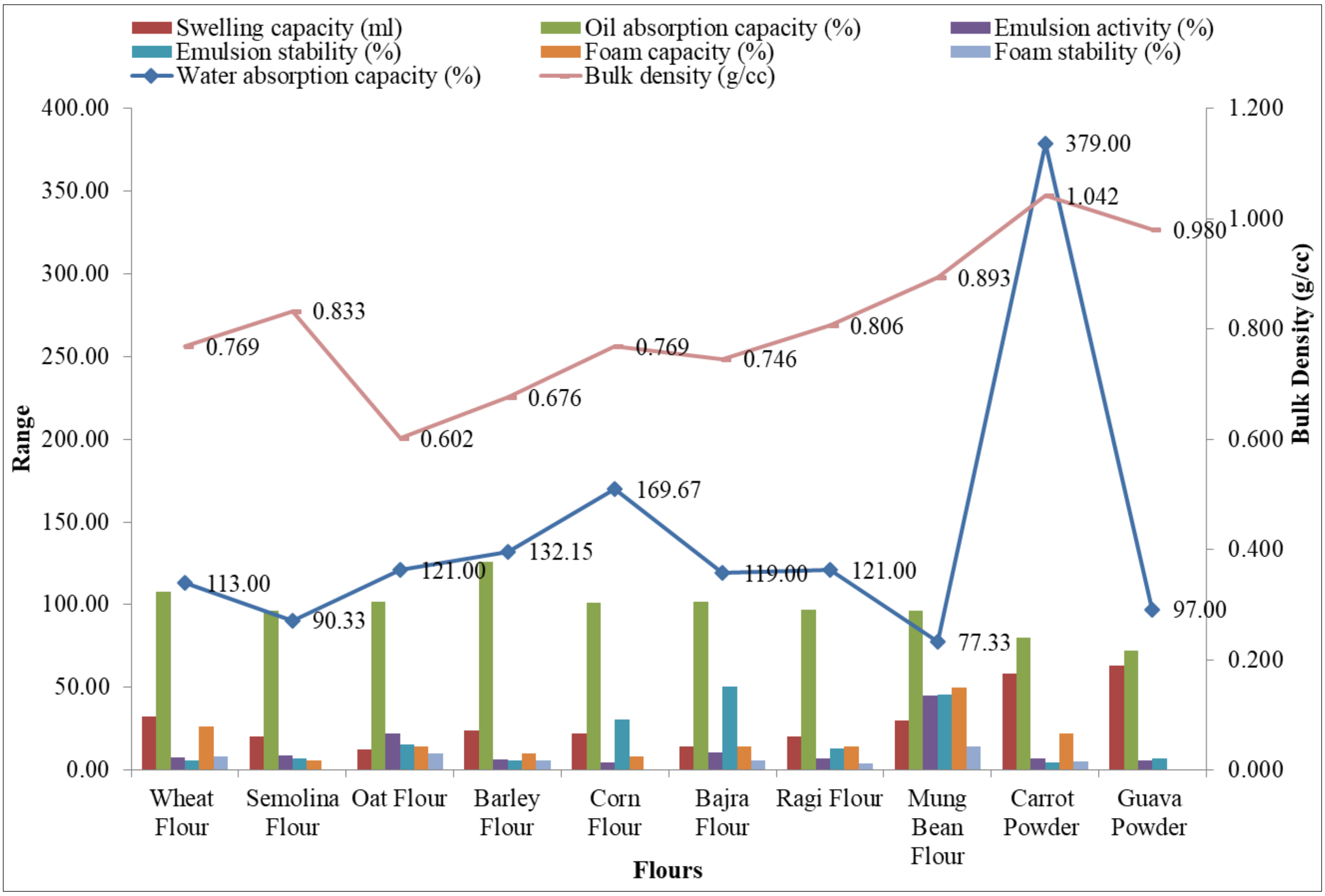

Fig 1: Effect of functional properties on individual flours

Physico-chemical properties of flours

The effect of wheat flour, semolina, barley flour, corn flour, bajra flour, ragi flour, mung bean flour, carrot powder, guava powder and oat flour on physico-chemical properties (moisture content, protein, fat, ash, pH, crude fiber, carbohydrate, energy and optical density) of individual flours were analysed and presented in Table 2 and Fig. 2.

The moisture content of flours was observed from 3.80 to 6.33% among all the flours. The highest moisture content was observed in carrot flour (6.33%) while lowest in oat flour

(3.80%). The protein content of flours was observed from 11.06 to 15.68% among all the flours. The highest protein content was observed in mung bean flour (15.68%) while lowest in semolina flour (11.06%). The fat content of flours was observed from 1.98 to 4.65% among all the flours. The highest fat content was observed in corn flour (4.65%) while lowest in guava powder (1.98%).

The crude fibre of flours was observed from 2.68 to 6.65% among all the flours. The highest crude fibre was observed in oat flour (6.65%) while lowest in carrot powder (2.68%). The ash content of flours was observed from 1.67 to 3.13% among all the flours. The highest ash content was observed in barley flour (3.13%) while lowest in semolina flour (1.67%). The pH of flours was observed from 4.07 to 6.81 among all the flours. The highest pH was observed in wheat flour (6.81) while lowest in guava powder (4.07). The carbohydrate of flours was observed from 70.54 to 74.61% among all the flours. The highest carbohydrate was observed in bajra flour (74.61%) while lowest was in carrot powder (70.54%). The energy of flours was observed from 358.51 to 383.57 Kcal among all the flours. The highest energy was observed in corn flour (383.57 Kcal) while lowest in guava powder (358.51 Kcal). The optical density of flours was observed from 0.013 to 0.865 among all the flours. The highest optical density was observed in semolina flour (0.865) while lowest in wheat flour (0.865).

Table 2: Physico-chemical properties of individual flours

Flour	Moisture Content (%)	Protein (%)	Fat (%)	Crdue Fibre (%)	Ash (%)	pH	Carbohydrate (%)	Energy (Kcal)	Optical density
Wheat Flour	3.93±0.306	13.65±0.055	3.65±0.083	4.36±0.037	2.14±0.122	6.81±0.062	72.27±0.196	376.52±1.347	0.013±0.0032
Semolina Flour	5.53±0.115	11.06±0.091	4.50±0.080	3.65±0.046	1.67±0.115	6.41±0.015	73.59±0.211	379.10±0.717	0.865±0.0111
Oat Flour	3.80±0.200	12.65±0.241	2.65±0.059	6.65±0.099	2.73±0.115	6.35±0.072	71.52±0.142	360.52±0.473	0.027±0.0010
Barley Flour	4.73±0.231	14.65±0.172	3.40±0.046	2.65±0.088	3.13±0.231	6.09±0.010	71.43±0.209	374.93±1.047	0.077±0.0017
Corn Flour	4.60±0.200	12.65±0.100	4.65±0.035	3.12±0.045	2.20±0.200	6.21±0.023	72.78±0.168	383.57±1.027	0.020±0.0021
Bajra Flour	5.00±0.529	11.69±0.065	2.65±0.030	4.25±0.070	1.80±0.200	6.62±0.069	74.61±0.670	369.05±3.151	0.078±0.0074
Ragi Flour	4.53±0.115	14.69±0.266	2.66±0.033	4.65±0.069	2.33±0.115	5.95±0.012	71.13±0.209	367.23±0.232	0.023±0.0015
Mung Bean Flour	5.73±0.306	15.68±0.059	3.68±0.084	4.41±0.062	2.93±0.115	6.71±0.010	67.56±0.162	366.09±1.070	0.084±0.0021
Carrot Powder	6.33±0.115	13.65±0.045	4.20±0.080	2.68±0.088	2.60±0.200	5.70±0.021	70.54±0.121	374.55±0.881	0.192±0.0010
Guava Powder	6.20±0.200	12.65±0.012	1.98±0.045	3.98±0.040	2.67±0.115	4.07±0.025	72.52±0.129	358.51±0.246	0.612±0.0091

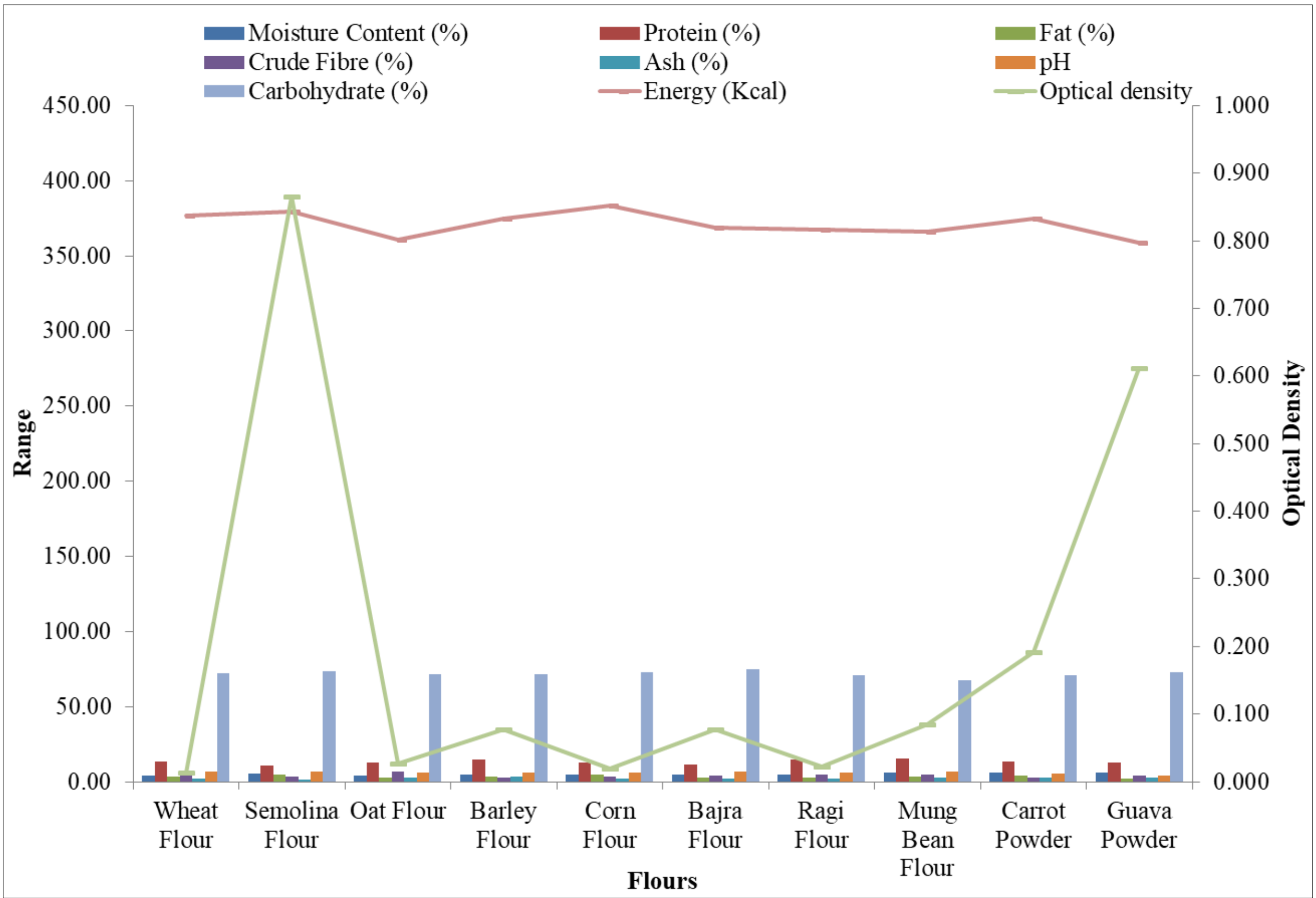

Fig 2: Effect of physico-chemical properties on individual flours

Conclusions

Texture and structure of semolina was also affected the water absorption capacity due to higher mechanical strength (hardness) among the other flour. So semolina showed lowest water absorption capacity as compared to other. In another case carrot powder reported highest value of WAC due to very fine particles of carrot powder. So ragi flour showed lowest foam capacity as compared to other flour. In another case mung bean flour reported highest level of foam stability due to depend on protein content and carbohydrate of the mung bean flour. The oat flour showed lowest swelling capacity as compared to other flours. In another case, guava powder had highest value of swelling capacity due to very fine particles and pH of guava powder.

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