International Food Research Journal 23(4): 1514-1522 (2016)
Journal homepage: *http://www.ifrj.upm.edu.my*

Quality evaluation of novel cookies prepared by supplementing with fresh turmeric flower (*Curcuma longa* L.) extracts as a value added functional ingredient

[1]Nur Syakila Azmi, [1*]Rajeev Bhat and [2]Yeoh, T.K.

[1]*Food Technology Division, School of Industrial Technology, Universiti Sains Malaysia, Penang 11800, Malaysia*
[2]*School of Hospitality, Tourism and Culinary Arts, Taylor's University, Lakeside Campus, Subang Jaya 47500, Selangor, Malaysia*

Article history

Received: 24 April 2015
Received in revised form: 19 November 2015
Accepted: 2 December 2015

Keywords

Turmeric flower
Cookies
Composition
Antioxidant Activity
Texture
Sensory Quality
Colour analysis

Abstract

Turmeric flowers, which have rich traditional culinary values, were used to produce novel formulated cookies. Aqueous extracts of fresh turmeric flowers (5, 10, 15 and 20%) were used as an added ingredient in cookies (with 0% as a control or those cookies without flower extracts). Results revealed significant differences in the proximate composition within all the formulated cookies. Cookies prepared with higher extraction levels of turmeric flowers (20%) exhibited lower antioxidant activity (% inhibition of DPPH radical). This can be attributed to the degradation of heat sensitive antioxidant compounds owing to the baking process. With regard to colour value, overall only 'a*' value (redness) was found to significantly vary among all the formulated cookies. Texture analysis results showed cookies with higher level of turmeric flower extracts to require least compression force. Further, results of sensory quality evaluation revealed control cookies to gain highest score for overall acceptability (5.70), followed by 10% (5.13) and 5% (5.07). As the consumers (panellists) are more familiar with the taste of normal cookies (control batch), this might have hindered them to accept novel cookies prepared using turmeric flower extracts. Overall, all the formulated cookies were found to be devoid of any microbial contamination. Results generated from this study is envisaged to not only popularize turmeric flowers as an value added functional food ingredient in cookies or other bakery based products, but is also expected to provide a valuable market for formulating healthy cookies using other flower extracts.

Introduction

Cookies are well appreciated bakery based products that have been devoured owing to their low-cost, but with rich nutritional qualities. Cookies can be a reliable, ready-to-eat and an easily accessible source of instant energy. Besides, majority of the cookies marketed have an extended shelf-life compared to some of the other popular bakery based products. This is mainly due their low moisture or water activity levels. The basic ingredient of cookies usually comprises of a flour base, sugar and fat (as the 3 main ingredients) (Sudha *et al*., 2007; Pareyt and Delcour, 2008; Mamat *et al*., 2010; Kweon *et al*., 2014). Supplementing cookies with functional ingredients is an ongoing trend, especially in the foods industries. Cookies which are augmented with natural plant extracts can impart rich health benefits and can have high potential to be tapped in local and international markets. In the present study, we attempted to use turmeric flower as an added functional ingredient, with an aim to enhance the overall qualities of the cookies.

Turmeric plants (*Curucma longa*; family Zingiberaceae) are cultivated for its rhizome in majority of the tropical regions, to be used as a flavouring agent. Turmeric rhizome has been proved to possess rich therapeutic potential and are traditionally (routinely) used in Indian cuisine as well as in other Asian foods as a spice (flavouring agent), as a natural preservative, as well as for imparting colour to the food. The taste of turmeric is described as peppery and imprecisely bitter (Balakrishnan, 2007). Turmeric plants inflorescence is a spike (funnel shaped), which is covered with green to white coloured bracts, bearing yellow coloured flowers (5 to 5.5 cm long) without any production of fruits (Jaggi, 2012). Turmeric flowers are reported to be a rich source of essential oils, comprising mainly p-cymen-8-ol (26%) (Neettiyath *et al*., 2002). In Malaysia, traditionally turmeric flowers or flower buds are consumed as 'ulam' (a raw vegetable salad) or are

*Corresponding author.
Email: *rajeevbhat1304@gmail.com, rajeevbhat@usm.my*
Tel: +60 4653 5212; Fax: +60 4657 3678

cooked with rice to impart a special flavour (aroma). Owing to the presence of natural aromatic floral oil (which can possess antioxidant and antimicrobial activities) as well as reported traditional uses, we tried to explore for turmeric flowers in this study. Several research studies have been reported on the prospective culinary and therapeutic uses of turmeric rhizome (Anonymous, 2001; Thomas-Eapen *et al*., 2009; Schaffer *et al.*, 2011; Prafulla *et al.*, 2013; Devassy *et al*., 2015). However, probable use of turmeric flowers as a value added food ingredient in bakery based products such as those of cookies, still remains unexplored.

In this study, we intended to produce cookies by utilizing turmeric flower extracts (aqueous extracts at concentrations level of 5%, 10%, 15% and 20% with 0% serving as control). The cookies were evaluated for their overall qualities (such as the composition, texture, colour, sensory attributes and microbial load). Results generated from this study is envisaged to not only popularize turmeric flowers as an value added functional food ingredient in cookies or other bakery based products, but is also expected to provide a valuable market for formulating healthy cookies using other flower extracts.

Materials and Methods

Materials

Fresh, handpicked turmeric flowers (*Curcuma longa* L.) were bought from a local market vendor in Ipoh region of Malaysia, and were used to prepare formulated cookies. Flowers were initially screened to ensure they are free from any physical, insect or microbial damages. Ingredients such as the wheat flour, brown sugar, margarine, milk powder, oats, baking powder, soda bicarbonate and salt for the preparation of cookies were of high food quality grade (purchased from Tesco Extra Supermarket, Penang, Malaysia).

Turmeric flower extracts and preparation of cookies

After fetching to the processing laboratory (at Food Technology Division, Universiti Sains Malaysia), the flowers were surface washed carefully with running tap water to remove all the adherent soil particles (if any) and unwanted dust particles. The flower petals were cautiously removed using a stainless steel sterilized scissors and knife.

Followed by this, fresh turmeric flower extracts were prepared at different concentration levels of 5, 10, 15 and 20% by blending them with potable water in a kitchen blender (Panasonic, MX 898M, Malaysia). The total amount of flower extracts added into the cookies formulation was calculated based on the weight of flour (wheat) and further substituted with adequate portion of water. A control set of cookies formulation was maintained without any addition of flower extracts. All the cookies were prepared based on the standard method proposed by AACC, 10- 3.01 (AACC, 2000) with slight modifications. In Figure 1 the flow chart highlighting the process of cookies preparations is depicted.

Proximate composition

The cookies were analyzed for proximate composition based on the standard method available (AOAC, 2000). Samples were analyzed for moisture (by using IR- moisture analyser, pre-heated/calibrated for 10-15 min.; Denver Instrument IR-30), crude fat (Soxhlet extraction method), protein (micro-Kjeldahl Method) and ash contents. The water activity in the samples was determined by using water activity meter. The amount of carbohydrate and energy values of the cookies was determined based on calculations.

The carbohydrate content was determined using the following equation:

% Carbohydrate = 100 - % (moisture + crude fat + crude protein + ash)

The amount of energy in a single cookie (~ 6-7 g) was determined by using the following equation:

$$E = (P \times 4) + (C \times 4) + (F \times 9),$$

Wherein, E = energy content (kcal/ 100g), P = % protein content, C = % carbohydrate content; F = % fat content (for each gram of protein and carbohydrate, energy obtained is 4 kcal whereas each gram of fat is 9 kcal of energy) (FAO, 2003).

All the above analysis was performed in triplicates and results were expressed on dry weight basis.

Analysis of antioxidant activity

Freshly prepared cookie samples (1 g) were mixed with 100 ml ethanol (96% v/v) in a conical flask (250 ml, and wrapped with aluminium foil to avoid light exposure), followed by overnight agitation of the mixture in an orbital shaker incubator (Infors, Model S III 927) (15-16 h, 150 rpm and 27^{o}C). Further, after the time period, the extracts were filtered using Whatman No. 1 filter paper to obtain a clear solution, which was used as a working sample. The antioxidant activity in the cookies were determined by using 2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging assay method (De Ancos *et al*., 2002). Results obtained was calculated

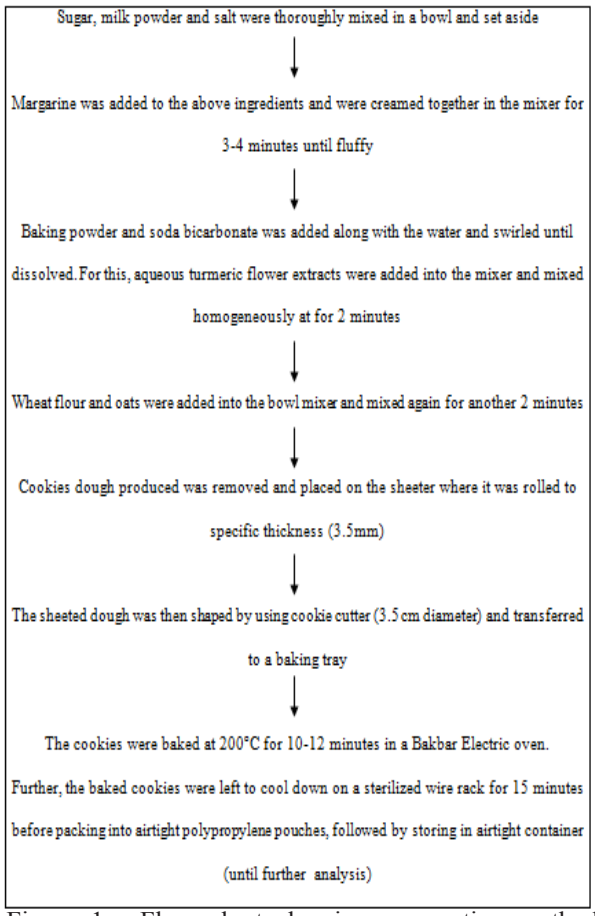

Figure 1. Flow chart showing preparation method employed for cookies

and were expressed as % inhibition of DPPH by using the following formula

% inhibition of DPPH = Abs control – Abs sample extract ÷ Abs control × 100

Colour measurement

Colour analysis of the cookies was determined by using a Minolta Spectrophotometer CM 3500-d (Osaka, Japan) with a medium target masks. The colorimeter was pre-calibrated with zero calibration box (CM-A124) followed by white calibration plate (CM-A120). The values of lightness L^*, redness a^* and yellowness b^* were recorded for each of the formulations.

Texture analysis

Texture properties (hardness and fracturability values) of all the cookies were determined by using a TA-XT Plus Texture Analyser (Stable Micro System Ltd., Surrey, England). The hardness was measured by employing a cylindrical probe P/2 fitted with a 5 kg cell load. The TA settings comprised of: Test mode, Compression; Pre-test speed, 1.00 mm/s; Test speed, 0.50 mm/s; Post-test speed, 10.0 mm/s; Distance, 5.00 mm; Trigger force, auto, 5 g. The cookies samples to be analysed were placed on a heavy duty platform (HDP/90) with a holed plate. On attaining the requisite trigger force, the force was increased steadily until the cookies broke into pieces. The initial significant peak force obtained from the resulting curve was considered as the 'initial fracture force' and the absolute peak force obtained was considered as 'hardness' of cookies.

Sensory quality evaluation

Freshly prepared cookies were evaluated for sensory quality attributes by employing 30 semi-trained panellists (consisting of students and staff of Food Technology Department, Universiti Sains Malaysia). The parameters evaluated included: odour, colour, flavour, crispiness, appearance and overall acceptability, which were all assessed by applying a 7 point hedonic scale: (1 = dislike extremely; 4 = neither like nor dislike; 7 = like extremely). The cookies were coded with a 3-digit random numbering and presented to the panellists on a plate. All the other essential pre-requisite standard parameters required to perform sensory analysis under a laboratory conditions were implemented

Microbiological analysis

Microbiological analysis included determining the total plate counts (TPC) of aerobic bacteria as well as those of total fungi and yeast (TYMC counts) in both a control and supplemented cookies. Standard methods were adopted for doing the analysis (Bacteriological Analytical Manual, BAM method, 2011; Bhat *et al*., 2011).

Statistical analysis

Results attained in this study are expressed as mean ± standard deviation of 3 independent replicates. Followed by this, we performed one-way analysis of variance (ANOVA) and Duncan's multiple range tests (SPSS software program, Version 16.0, SPSS Inc., Chicago, IL, USA). The level of significance was deliberated at $p \leq 0.05$.

Results and Discussions

Proximate composition

The results obtained for proximate composition of cookies incorporated with different concentration levels of turmeric flower extracts (5%, 10%, 15% and 20%) is depicted in Table 1. Significant differences in the moisture content were recorded in all the formulated cookies compared to control batch of cookies ($p < 0.05$). The incorporation of turmeric flower extracts into cookies showed an increasing trend

Table 1. Proximate composition and percentage inhibition of DPPH. radical in cookies prepared by supplementing with different concentrations levels of fresh turmeric flower extracts (on dry weight basis; mean n= 3± standard deviation)

Cookies Sample	Composition (%)							% Inhibition of DPPH
	Moisture	Water activity	Ash	Crude Protein	Crude Fat	Carbohydrates	Energy (kcal)	
Control	4.30 ± 0.70^{c}	0.44 ± 0.04^{a}	1.76 ± 0.05^{a}	7.00 ± 0.06^{a}	19.42 ± 0.56^{a}	67.53 ± 1.19^{a}	472.86 ± 1.81^{a}	14.53 ± 1.48^{a}
5% TF	4.37 ± 0.32^{a}	0.45 ± 0.01^{a}	1.83 ± 0.06^{a}	6.94 ± 0.16^{a}	19.69 ± 0.52^{a}	67.17 ± 0.69^{a}	473.66 ± 3.03^{a}	15.12 ± 0.57^{a}
10% TF	5.47 ± 0.41^{c}	0.49 ± 0.03^{c}	2.06 ± 0.47^{a}	6.95 ± 0.18^{a}	22.50 ± 0.28^{b}	63.01 ± 1.05^{b}	482.37 ± 1.84^{b}	12.12 ± 0.00^{a}
15% TF	6.39 ± 0.09^{b}	0.54 ± 0.00^{b}	1.82 ± 0.06^{a}	6.89 ± 0.11^{a}	22.76 ± 0.70^{b}	62.14 ± 0.84^{c}	480.96 ± 3.20^{b}	11.95 ± 1.91^{a}
20% TF	7.44 ± 0.20^{a}	0.62 ± 0.07^{a}	1.86 ± 0.21^{a}	6.76 ± 0.03^{a}	22.20 ± 0.23^{b}	61.75 ± 0.40^{c}	473.80 ± 0.44^{a}	11.36 ± 0.00^{a}

TF = Turmeric flower extract; Mean values within the same column with the same superscript letter were not significantly different (p>0.05)

in the moisture compared to control. Earlier, Manley (2000) have indicated that moisture levels in cookies should range between 2.5-3.0%. However, in this study a higher moisture content was recorded, which can be attributed to higher water binding capacity of the ingredients used (wheat flour, oats, brown sugar, margarine, milk powder) for cookies formulation. Besides, as water was used as an extraction solvent to obtain turmeric flower extracts, this might have had an influence on the overall moisture content of the prepared cookies. Based on our results, it was clear that a positive correlation occurs between turmeric flower extracts and the elevated moisture levels in cookies. It is a well-accepted fact that cookies tend to differ from other bakery based products (such as bread, cake, and others) mainly based on the low moisture levels. Moisture levels less than 5-6 % in cookies can be valuable for long term storage and extend the shelf life, as well as to minimize the risks of microbial contamination. Apart from the moisture content, incorporation of turmeric flower extracts into cookies resulted in an increased water activity levels, which can be attributed to active interactions that can occur between aqueous extracts of flowers and the dough. In addition, it needs to be reminisced that water molecules tends to strongly bound to food particles in a dry food such as that of the cookies, thus rendering it to be capable of enhancing the bound water contents, leading to detection of enhanced water activity levels. Infact low water activity level (aw < 0.6) in cookies can be advantageous with regard to retarding the proliferation of a spoilage microorganisms during storage (Smith *et al*., 2004).

With regard to the crude protein content, though a reduction was recorded between control and formulated samples, they were statistically insignificant (P>0.05). This indicates that turmeric flowers might have negligible amounts of protein, as well as the baking process might have reduced the non-heat stable proteins too. Regarding crude fat, except for cookies supplemented with 5% turmeric flower extract, all other samples showed significant increase compared to cookies. Fat content in cookies is a vital basic component, and if reduced can play a significant role in altering the flavour, appearance and texture (Rankin, 2000; Maache-Rezzoug *et al*., 1998). However, excessive amounts of fat might not be considered healthier. So also, excessive fat levels can lead to oxidation process in the cookies, especially during extended storage. However, we envisage that rancidity problems can be minimized by addition of synthetic or natural antioxidant rich compounds such as that of turmeric flowers, which can be explored in future studies.

The ash content, an indication of mineral composition in a food, showed non-significant increase in the formulated cookies compared to control. The increase in ash in cookies supplemented with turmeric extracts can be attributed to the additional minerals that might have naturally existed in the turmeric flowers. Regarding the carbohydrates, significant decrease was recorded in cookies supplemented with turmeric flowers (> 10%), compared to control cookies. Results on the energy level for the cookies are stated in calorie per 100 g serving. Our results showed only two formulations of cookies (10% and 15%) to exhibit significant differences when compared to the control cookies.

Antioxidant activity measured as percent inhibition of DPPH. activity

Supplementing a bakery based food product

Table 2. Colour measurement for different of formulations of cookies (mean n= 3± standard deviation)

Cookies sample	Colour values		
	L^*	a^*	b^*
Control	59.32 ± 0.81^{ab}	7.34 ± 1.14^{a}	32.14 ± 0.64^{a}
5% TF	60.13 ± 0.97^{a}	7.09 ± 1.43^{a}	32.80 ± 0.72^{a}
10 % TF	58.98 ± 1.68^{ab}	6.66 ± 0.38^{ab}	32.66 ± 0.22^{a}
15% TF	57.69 ± 0.75^{b}	6.17 ± 0.80^{ab}	32.63 ± 0.24^{a}
20% TF	58.72 ± 0.64^{ab}	4.94 ± 0.65^{b}	31.80± 0.10^{a}

TF = Turmeric flower extract; Mean values within the same column with the same superscript letter were not significantly different (p>0.05)

Table 3. Texture properties (hardness and fracturability value) of different formulations of cookies (mean n= 3 ± standard deviation)

Cookies Sample	Area 'Hardness' (g.sec)	Linear Distance 'Fracturability' (g.sec)
Control	16399 ± 90.16^{a}	3753 ± 236.21^{a}
5% TF	14731 ± 436.46^{c}	3494.8 ± 16.65^{a}
10 % TF	23537 ± 352.61^{a}	5207 ± 378.51^{a}
15% TF	11381 ± 71.10^{d}	1758.6 ± 70.81^{c}
20% TF	10697 ± 382.81^{e}	1741.7± 123.25^{c}

TF = Turmeric flower extract; Mean values within the same column with the same superscript letter were not significantly different (p>0.05)

with natural plant based antioxidant compound can be considered safe from the consumer point of view. Besides, addition of natural antioxidant compounds can enhance the shelf-life by reducing microbial contamination and rancidity. Antioxidants assay by employing 1,1-Diphenyl-2-picryl hydrazyl (DPPH) method is the most popular and routinely employed method to determine radical scavenging activities in a given material. This method is derived based on the reduction of stable DPPH free radical, and measured spectrophotometrically at 517 nm.

In this study, percentage inhibition of DPPH radical in fresh turmeric flower extract (aqueous) was recorded to be 23.08 % (± 0.01). In turmeric, various types of antioxidant rich polyphenolic compounds (terpenoids, curcuminoids, etc) have been identified which can impart higher radical scavenging activities (Li *et al*., 2011; Lekshmi *et al*., 2011). In addition turmeric flower is reported to contain essential oil of approximately 0.3% (Jaggi, 2012), which can play a significant role, even at threshold levels.

In Table 1, the result obtained for percentage inhibition of DPPH free radical activity of cookies prepared using different concentration of fresh turmeric flowers. Our results showed lowering of antioxidant activity in cookies correlating to the proportion/concentration of turmeric flower extract added. This can be attributed to loss of some of the antioxidant compounds during baking process of cookies. Generally, the antioxidant levels in cookies should have coincided with the concentration of the added turmeric flower extracts. However, in this study we determined antioxidant activities only as percent inhibition of DPPH. radical. There might be several other heat sensitive antioxidant compounds present in the flower extracts that can contribute significantly to the total antioxidants activities. Degradation of these heat sensitive compounds might have resulted in the recorded decreased levels in the percent inhibition of DPPH. In this study, cookies were baked around 200^{o}C, and the temperature used might have resulted in the loss of antioxidant activity. Further, the decomposition, volatilization and interaction of antioxidant compounds (such as polyphenols or tannins) with other components of dough can also influence the products antioxidant capacity (Dykes and Rooney, 2006; Hamama and Nawar, 1991). Hence, further studies are warranted to evaluate other antioxidant rich compounds in the turmeric flowers, and how these compounds degrade on incorporation into bakery based food products requiring baking at high temperature.

However, overall, in this study, still the antioxidant activity could be retained in the formulated cookies compared to control. Further, higher inhibition activity in control cookies can be attributed to the presence of wheat flour and oats. Our results were well anticipated, as various types of food processing methods such as dehydration, blanching, steaming, cooking, and other thermal treatments can influence the antioxidant activity (Jonsson, 1991; Karrar, 2014). Further studies can be initiated to evaluate the influence of oxidation process in cookies with added fat.

Colour measurements

Colour of a food product is the foremost quality parameter appraised by a consumer. For measuring the colour of cookies, three basic parameters were

Table 4. Sensory evaluation of different cookies formulations prepared by using turmeric flower extracts (mean n= 30 ± standard deviation)

Cookies Sample	Colour	Appearance	Aroma	Taste	Texture	Overall acceptability
Control	5.40 ± 1.04^{a}	5.47 ±1.28^{a}	5.13 ± 1.17^{a}	5.53 ± 1.01^{a}	5.47 ± 1.20^{a}	5.70 ±0.91^{a}
5% TF	5.37 ± 1.22^{a}	5.13 ± 1.20^{ab}	5.53 ± 1.14^{a}	4.87 ± 1.59^{ab}	5.50 ± 1.39^{a}	5.07± 1.31^{ab}
10% TF	5.00 ± 1.15^{a}	4.90 ± 1.30^{ab}	5.03 ± 1.13^{a}	4.87 ± 1.14^{ab}	5.27 ± 1.26^{a}	5.13± 1.22^{ab}
15% TF	4.80 ± 1.24^{b}	4.63 ± 1.16^{b}	4.80 ± 0.96^{a}	4.73 ± 1.39^{b}	5.13 ± 1.01^{a}	4.90 ± 1.19^{b}
20% TF	4.77 ± 1.41^{b}	4.43 ± 1.41^{b}	4.57 ± 1.33^{a}	4.43 ± 1.59^{b}	4.40 ± 1.52^{b}	4.50 ± 1.53^{b}

TF = Turmeric flower extract; Mean values within the same column with the same superscript letter were not significantly different ($p>0.05$)

used, which included: the L^*, a^* and b^* values. The L^* value corresponds to level of lightness or whiteness, a^* value specifies redness or greenness and b^* value indicates yellowness of the sample. In Table 2, results obtained for colour analysis of cookies is provided. It was observed that 5% of turmeric flowers incorporated cookies to exhibit highest L^* value, indicating to have higher lightness. Whereas, with regard to a^* value, significant reduction was observed, which were correlated to the concentration of flower extracts added. The 20% level of turmeric flower extracts incorporated cookies had the lowest a^* value among all the samples. However, no significant differences were recorded for the b^* value in the cookies analyzed. Overall, cookies with 20% of turmeric flower extracts had the lowest value. The observed differences can be attributed to uneven exposure of the surface area of cookies to the heat applied (in oven) during baking process. In addition, colour of cookies can depend on the amount of added sugars present in the dough, which can influence induction of Maillard reactions during baking process. Some of the vital components contributing to the colour includes the protein, antioxidants, fat content as well as the baking time (Cronin and Preis, 2000). Earlier, Borrelli *et al.* (2003) have indicated proteins and carbohydrates (glucose) to be the main component responsible for browning reactions and influencing the organoleptic properties of bakery based products. Infact, humidity or moisture present in oven atmosphere during initial stages of baking can be highly effective with regard to the development of colour in cookies (Wade, 1988).

Texture analysis

Texture analysis is usually performed to determine the hardness and the range of fracturability of cookies on application of force. Higher the force required to compress a sample, larger will be the hardness value. Test results obtained in this study for the formulated cookies gave a standard mean area under the curve and mean linear distance values (see Table 3). Result revealed significant differences ($p<0.05$) between the hardness value of control cookies and the other cookies incorporated with turmeric flower extracts. Cookies with highest concentration of turmeric flower extracts (20%) were found to have considerably lowest value of hardness compared to other cookies. Regarding the fracturability of cookies (trigger force of 5 g), results indicated a linear distance in the analysis. The main function of linear distance is to calculate the length of an imaginary line adjoining all the points in a selected region. Higher the linear distance value, the effortless will be the sample fractured. Results showed significant differences between control cookies and all the formulated cookies supplemented with turmeric extracts of 10, 15 and 20%. The variation observed can be attributed to the structure of the cookies as well as ingredients added, which might cause large force fluctuations. For examples, fiber content in oats might tremendously contribute to the increase in water holding capacity in the dough, and thus leading to a harder texture in the cookies. Besides, addition of the turmeric flower extracts to cookies slightly reduced the force required to break the cookies, which indicates cookies to have become more fragile compared to the control batch. This can be probably attributed to the interactions of flower extracts with flour components and other ingredients which were used during dough preparation. During cookie preparations, mixing tends to evenly disperse the added ingredients, thus supporting the absorption

of water, instead of developing into a factual dough structure (Huebner *et al*., 1999). According to Kontogiorgos (2011), spreading out of gluten network is shaped between glutenin and gliadin, resulting in the hardness of cookies. Higher gluten levels can reduce the dough weight, hardness, density and stickiness (Pareyt and Delcour, 2008). Moreover, ash content in the samples can also significantly affect the basic gluten network formation in the dough, leading to poor texture.

Hardness value can also be used for analysing freshness as well as scrumptiousness of cookies. Maintaining the hardness in cookies is a pre-requisite to retain the original shape during transport as well as distribution until it reaches the consumers intact without easily getting broken down. However, depending on the ingredients and formulations, the chewing properties can differ. Besides, Slade *et al.* (1993) have correlated fracturing to the level of collapse during end stages of baking. Post-baking process is carried out in the oven, after which cookies are cooled. During this phase, starch and proteins bind together (solidify), thus rendering cookies to be firm and rigid. Also, after the completion of cooling, sugars tend to re-crystallize on crust portion (Hoseney, 1994), especially during storage, thus providing the necessary crispiness texture to cookies. Overall, it should be noted that quantity of fat can play a vital role in determining the texture and taste of the cookies rather than sugar or the flour content (Campbell *et al*., 1994; Sanchez *et al.*, 1995; Maache-Rezzoug *et al.*, 1998).

Sensory quality evaluation

Results obtained for sensory quality evaluation is presented in Table 4. This analysis was carried out to determine the consumers (panellists) acceptability for turmeric flower supplemented cookies. In this study we used a 7-point hedonic scale (level 1 extremely dislike until level 7 extremely like), which were based on six attributes, including those of: colour, appearance, aroma, taste, texture and overall acceptability.

Visual colour represents an important quality criterion of cookie, as perceived in the consumers mind/eye. In this study, statistical differences were recorded between control and formulated cookies at 15% and 20% levels. This indicates that the panellists/consumers are well acquainted with a wide array of different coloured cookies. With regard to appearance, results showed significant differences between control and cookies incorporated with turmeric flower extracts at 15% and 20% levels. This indicates that turmeric flowers incorporated cookies to have varied appearance compared to control cookies, which could be easily detectable by the panellists.

Sensory qualities based on aroma attributes, which is a representative of flavour, showed non-significant differences in formulated cookies. Overall, incorporation of turmeric flower extracts might not have had an influence on the aroma characteristics of cookies. This is an indication that panellists are unable to determine the floral volatile compounds in the cookies. However human perception on aroma compounds can differ with that instrumental analysis. Besides, the volatile compounds in the turmeric flower might have also been lost during baking process.

Taste, a vital quality marker, is an indication of the mouth-feel, sensed by tongue or the mouth receptors (de Man, 1999). Cookies supplemented with 15% and 20% of turmeric flower extracts were found to be significantly different compared to control cookies. This result indicates that majority of the panelists were not ready to accept the intense taste of turmeric flower. From the discussion perceived with the panellists, it was clear that turmeric flowers tend to produce bitter taste and off-flavour at higher concentration levels. Furthermore, panellists preferred control batch of cookies, which indicates there unpreparedness to explore for novel taste and prefer the established way of baked cookies.

Concerning the texture of cookies (crispiness or the hardness) based on sensory qualities; the score given by the panellists indicated significant differences between control cookies and cookies prepared by incorporating 20% of turmeric flower extracts. These results were comparable to the instrumental texture analysis results. The panellists gave higher preference for harder and crispy cookies. Finally, regarding the overall acceptability of cookies, control cookies gained significantly highest score (5.70) followed by cookies made with 10% incorporation of turmeric flower extracted (5.13) and 5% levels (5.07). As the consumers (panellists) are more familiar with the taste of normal cookies (control batch), this might have hindered them to accept novel cookies prepared using turmeric flower extracts. However, once the formulated cookies are standardized further with regard to improving the tastes, this might gain more acceptability among the consumers.

Microbiological analysis

Stability towards microbial contamination can be an important criterion in cookies to for safety reasons as well as to extend the shelf life. However, reports

available on microbiological qualities of cookies are scarce, as cookies contain low amount of moisture and water activities. In this study, microbial quality was determined based on total plate count (TPC) and yeast and mould counts (TYMC). Our results showed all the cookies (control and those supplemented with turmeric flowers) to be devoid of any contamination. These results are on par with the opinion of Pitt (1975) and Smith (2004), who have stated that cookie or any other bakery products with low water activities needs to be devoid of any microbial contamination. Apart from low water activity and moisture in baked cookies, even if any contamination occurs during storage, presence of turmeric flowers in supplemented cookies can be expected to play a vital role in the preservation process.

Conclusions

In the present study, turmeric flowers were used at different formulations as an added functional ingredient to prepare novel cookies with enhanced flavour/taste and with potential therapeutic value. Results generated with regard to composition, colour, antioxidant activity, sensory, texture and microbiological qualities were encouraging providing more insights towards the possibilities to explore turmeric flowers as an added ingredient in preparation of novel or existing bakery products. From the present work, it can be concluded that incorporation of turmeric flower extracts into the cookies formulation to have enhanced the nutritional value. Besides, 5% and 10% levels of incorporation of flower extracts can be recommended to be the best formulations, as favoured by the sensory panellists. As phytochemicals rich turmeric flowers has never been explored as an added ingredient in bakery products development, further research studies are warranted to explore the retention of health promoting bioactive compounds in the formulated products as well as on the oxidative stability of the cookies. Further, detailed studies on shelf-life extension of the formulated cookies needs to be instigated to evaluate the products stability during extended storage conditions.

Acknowledgements

Research funds provided as RUI grant (No.1001/PTEKIND/814139, USM) for the corresponding author is acknowledged.

References

AACC. 2000. Approved Methods of the American Association of Cereal Chemists. Am. Assoc. Cereal Chem. Inc., St. Paul, Minnesota.

AOAC. 2000. Official methods of analysis. AOAC International, Gaithersburg, USA, 17th edition.

Anonymous 2001. *Curcuma longa* (turmeric). Monograph. Alternative Medicine Review 6 Suppl:S62-6.

Balakrishnan, K. V. 2007. Postharvest technology and processing of turmeric. In: Ravindran P. N, Nirmal Babu K, Sivaraman K, editors. Turmeric: The Genus *Curcuma.* Boca Raton, FL: CRC Press; pp. 193–256.

BAM. 2011. Bacteriological Analytical Manual: Department of Health and Human Services. U.S. Food and Drug Administration. Bacteriological Analytical Manual: 2011. Food Sampling and Preparation of Sample Homogenate. Retrieve from: *http://www.fda.gov/*(assess date December 2014).

Bhat, R., Nor Shuaidda Bt Che Kamaruddin, Min-Tze L. and Karim, A.A. 2011. Sonication ameliorates Kasturi lime *(Citrus microcarpa)* juice quality. Ultrasonics Sonochemistry 18(6): 1295-1300.

Borrelli, R.C, Mennella, C., Barba, F., Russo, M., Russo, G.L, Krome, K., Erbersdobler, H.F, Faist, V. and Fogliano, V. 2003. Characterization of coloured compounds obtained by enzymatic extraction of bakery products. Food and Chemical Toxicology 41: 1367–1374.

Campbell, L.A., Ketelsen, S.M. and Antenucci, R.N. 1994. Formulating oatmeal cookies with calorie-sparing ingredients. Food Technology 48(5): 98-105.

Cronin, K. and Preis, C. 2000. A statistical analysis of biscuit physical properties as affected by baking. Journal of Food Engineering 46(4): 217–225.

De Ancos, B., Sgroppo, S., Plaza, L. and Cano, M. P. 2002. Possible nutritional and health-related value promotion in orange juice preserved by high-pressure treatment. Journal of the Science of Food and Agriculture 82: 790–796.

deMan, J.M. 1999. Principles of Food Chemistry. Third Edition. Aspen Publishers, Inc. Gaithersburg, Maryland.pp.1- 497.

Devassy, J.G., Nwachukwu, I.D. and Jones, P.J. 2015. Curcumin and cancer: barriers to obtaining a health claim. Nutrition Reviews 73(3): 155-165.

Dykes, L. and Rooney, L.W. 2006. Sorghum and millet phenols and antioxidants. Journal of Cereal Science 44: 236-251

FAO. 2003. Food energy - methods of analysis and conversion factors. Report of a Technical Workshop, Rome, 3-6 December 2002. Food and Agriculture Organization of the United Nations Rome, 2003. *(http://www.fao.org/docrep/006/y5022e/y5022e00.htm; assess date December, 2014)*.

Hamama, A.A. and Nawar, W.W. 1991. Thermal decomposition of some phenolic compounds. Journal of Agricultural and Food Chemistry 39: 1063-1069.

Hoseney, R. C. 1994. Principles of cereal science and technology (No. Ed. 2). American Association of Cereal Chemists (AACC).

Huebner, F.R., Bietz, J.A., Nelsen, T., Bains, G.S. and Finney, P.L. 1999. Soft wheat quality as related to

protein composition. Cereal Chemistry 76: 650–655.

Jaggi, L. 2012. Turmeric, Curcumin and Our Life: A Review. Bulletin of Environment, Pharmacology and Life Sciences 1: 11-17.

Jonsson, I. 1991 Thermal degradation of carotenoids and influence of their physiological functions in M. Freidman (Ed.), Nutrition and toxicological consequences of food processing (p. 75–82). New York, NY, USA: Plenum Press.

Karrar, E.M.A. 2014. A review on: Antioxidant and its impact during the bread making process. International Journal of Nutrition and Food Sciences 3(6): 592-596.

Kontogiorgos, V. 2011. Microstructure of hydrated gluten network. Food Research International 44: 2582-2586.

Kweon, M., Slade L., Levine H. and Gannon, D. 2014. Cookie- versus cracker-baking--what's the difference? Flour functionality requirements explored by SRC and alveography. Critical Reviews in Food Science and Nutrition 54(1): 115-118.

Lekshmi, P.C., Arimboor, R., Raghu, K.G. and Menon A.N. 2011. Turmerin, the antioxidant protein from turmeric *[Curcuma longa]* exhibits anti-hyperglycaemic effects. Natural Products Research 26(17): 1654-1658.

Li, S., Yuan, W., Deng, G., Wang, P., Yang, P. and Aggarwal, B. 2011. Chemical composition and product quality control of turmeric (*Curcuma longa* L.), Pharmaceutical Crops 2: 28-54.

Maache-Rezzoug, Z., Bouvier, J.M., Allaf, K. and Patras, C. 1998. Effect of principal ingredients on rheological behaviour of biscuit dough and on quality of biscuits. Journal of Food Engineering 35: 23-42.

Mamat, H., Abu Hardan, M. O. and Hill, S. E. 2010. Physicochemical properties of commercial semi-sweet biscuit. Food Chemistry 121(4): 1029-1038.

Manley, D. 2000. Technology of Biscuits, Crackers and Cookies, Third Edition, Woodhead Publishing limited, Cambridge England, pp. 21-223.

Neettiyath, K.L., Tava A, Shafi, P.M,, John, S.P. and Chempakam B. 2002. Chemcila composition of essential oils of turmeric (*Curcuma longa* L.). Acta Pharmaceutica 52: 137-141.

Pareyt, B. and Delcour, J. A. 2008. The role of wheat flour constituents, sugar, and fat in low moisture cereal based products: A review on sugar-snap cookies. Critical Reviews in Food Science and Nutrition 48(9): 824–839.

Pitt, J.I. 1975. Xerophilic fungi and the spoilage of foods of plant origin, in Water Relation of Food (R.B. Duckworth, ed.) pp. 273–307, Academic Press, London.

Prafulla, S., Arjun, M. and Vidya, S. 2013. *Curcuma longa* Linn. A Phytochemical and Phytopharmacological Review.Research Journal of Pharmacognosy and Phytochemistry 5(2): 59- 68.

Rankin, L. L. 2000. Acceptability of Oatmeal Chocolate Chip Cookies prepared using pureed white beans as a fat ingredients substitute. Journal of The American Dietetic Association, 100(7): 831-833.

Sanchez, C., Klopfenstein, C. F. and Walker, C. E. 1995. Use of carbohydrate-based fat substitutes and emulsifying agents in reduced-fat shortbread cookies. Cereal Chemistry 72: 25-29.

Schaffer, M., Schaffer, P.M., Zidan. J. and Bar Sela. G. 2011. *Curcuma* as a functional food in the control of cancer and inflammation. Current Opinion in Clinical Nutrition and Metaboilc Care. 14(6): 588-597.

Slade, L., Levine, H., Ievolella, J. and Wang, M. 1993. The glassy state phenomenon in applications for the food industry: Application of the food polymer science approach to structure–function relationships of sucrose in cookie and cracker systems. Journal of the Science of Food and Agriculture 63: 133–176.

Smith, J.P., Daifas, D.P., El-Khoury, W., Koukoutsis, J. and El-Khoury, A. 2004. Shelf life and safety concerns of bakery products--a review. Critical Reviews in Food Science and Nutrition 44(1): 19-55.

Sudha, M.L., Vetrimani, R. and Leelavathi, K. 2007 Influence of fibre from different cereals on the rheological characteristics of wheat flour dough and on biscuit quality. Food Chemistry 100: 1365-1370.

Thomas-Eapen, N.E. 2009. Turmeric: the intriguing yellow spice with medicinal properties. Explore (NY) 5 (2):114-115.

Wade, P. 1988. Preparation of biscuit doughs. In: Biscuits, Cookies and crackers. The principles of the craft, Vol. 1, pp 18. London: Elsevier Applied Science.