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Research Article

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# Effect of Oat Incorporation on Textural Parameters of Dough and Sensory Quality of Biscuits

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## *ABSTRACT*

In view of their growing importance in human nutrition, incorporation of oats during the manufacture of short-dough type biscuits was studied. Rolled oats were incorporated at 25, 35 and 45% of refined wheat flour in short-dough type biscuit formulation. The oats incorporated dough exhibited less firmness as indicated by lower firmness value for 25% oats incorporation (21.73 N) as against 25.05 N for control dough measured by Texture Analyser. Sensory evaluation of biscuits prepared from the dough revealed that the biscuit made from 25% oat incorporated dough scored highest after control in most of the sensory attributes including overall acceptability. Sensory analysis indicated that oats incorporated biscuits scored less on body and texture owing to increased hardness and dry mouthfeel. The moisture and β- glucan contents were 2.94% and 0.7% for oats added biscuits (25% oats incorporation), respectively. It was concluded that good quality biscuits can be prepared by incorporating rolled oats in biscuit formulation.

***Key words:*** Biscuit, Oat, Dough, Texture analyser

## Introduction

Bakery products are consumed popularly throughout the world. As such there is a good scope for manufacture of varieties of those products by incorporating nutritional components. Notwithstanding the debate whether baked items are good for health, several 'health' products in bakery section are appearing on market shelves drawing attention of people. Biscuits seem to top the chart, because varieties of them have been introduced like fibre enriched, easily digestible, diabetic friendly, crispy and crumbly, different flavoured etc. According to some consulting groups (Anonymous a,b,c & d) [1-4], a satisfactory Indian biscuit market growth is indicated by a CAGR of 12.4% and will touch $11,792.3 million by 2027. The total production of biscuits in India is estimated to be around 30 lakh MT, but according to Statista, biscuits and cookies of over 632 thousand metric tons was produced in India during fiscal year 2020. The consumption of biscuits per capita in India is 2.1 kg, in comparison to 21.76 kg in Ireland which is highest, 4.25 kg in South East Asian and European countries and about10 kg in the USA. There is a growing demand and competition in the biscuit market and the manufacturers are striving to produce newer varieties by incorporating healthy ingredients. Attempts are being made to produce biscuits for giving energy, but also low energy as well as diabetic biscuits. Value addition in these ways is desirable proposition, however, sometimes may have to be compromised with the cost. Hence, low cost ingredients have to be tried for achieving the functionality. In this regard, incorporation of fibre and β-gucan seems to be plausible approach for enhancing functionality of biscuits.

Cereals are a good source of fibres for all class of people. Of all the cereals, oats (*Avena sativa* L.) have been touted as premium cereal because of their nutritional properties. As such, oats have been used in many of baked products [5]. Whole oats seeds have protein 11.27 – 17.18, fat 2.06 – 3.64, starch 57.91 – 64.21, carbohydrates 56.63 – 64.98, moisture

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11.57 -12.98, and ash 2.69 -3.62[6]. Whole grain oat flour contains 10-17% protein, 56-62% starch and sugars, 4-9% fat, 11-17% dietary fibre and 2-7% ß-glucan[7]. When oats are consumed, their total dietary fibre and β - glucan contents are responsible for controlling postprandial blood glucose, lipids, serum total and LDL cholesterol levels in blood, thus contributing to better health of consumers. [8,9]. Further, Food and Drug Administration (FDA) also recognized the efficacy of oat β-glucan to reduce the risk of coronary heart disease. This has helped manufacturers to claim health benefits for products containing a minimum of 0.75 g of oat β -glucan proportion.

Oat (*Avena sativa* L.) products are good sources of different dietary fibre components, such as mixed-linkage (1-3), (1-4)-β-D-glucan (also called β -glucan), arabinoxylans and cellulose. The neutral cell wall polysaccharide β -glucan has very good functional and nutritional properties. It achieves high viscosities at relatively low concentrations. Autio et al. (1987)[10] found that β -glucan solutions (concentration: 1%) have a low flow behavior index and a high consistency index in the power law model. Viscosity of β-glucan was stable over a wide range of pH (2–10) and decreased with increasing temperature[11]. The β -glucan content in oat (*Avena sativa*) varies between 2.3 and 8.5/ 100 g[12]. Oat bran is the outer casing of the oat. Its consumption is believed to lower LDL ('bad') cholesterol, and possibly to reduce the risk of heart disease. Oats contain more soluble fibre than any other grain, resulting in slower digestion and an extended sensation of fullness.

Therefore, looking into the nutritional importance of oats, it is naïve to surmise that oats incorporation into our daily consumed products might impart health benefits to the consumers thereby justifying the efforts of many researchers to incorporate them into baked and other foodstuffs. With this line of thinking, the present work was carried out and results are presented.

# Materials and methods

## Materials

The following ingredients were procured from local market: refined wheat flour, icing sugar and common salt. Shortening (aerated bakery shortening) of BESS Brand made by KOG-KVT Food Products (India) Pvt. Ltd., Tuticornin was procured from a nearby well known bakery. 'Quaker' brand oats, soy lecithin liquid supplied by Trump Crown (India) Pvt. Ltd and Nandini brnad spray dried milk powder were used in the study. Glycerol monostearate was purchased from Victory Essence Mart, Bangalore, India, who is a reputed supplier of food ingredients. The packaging material employed in the study was metalized polystyrene of 61.5 μM thickness procured from Innoflex Laminators Pvt. Ltd. Bangalore, India.

## Method of biscuits preparation

The proportion of ingredients used in the study was as per the work of Sudha et al. (2007)[13], but minor variations were made. The ingredients used in g were: refined wheat flour 100, salt 1.5, milk powder 4, icing sugar 20, fat 50, lecithin 0.25, glycerylmonostearate (GMS) 0.5 and water 15 ml. Grinding of rolled oats yielded a fine powder which was incorporated in biscuit formulation at three levels viz. 25, 35 and 45% levels. The method employed for preparation of biscuits was that of short dough type [14].

***Creaming/ Dough preparation***: Refined wheat flour, oats flour, salt and milk powder were considered as dry items and hence sieved well to attain uniformity. Shortening was 'creamed' well for 5 min and then added with lecithin and GMS. Into this, icing sugar and dairy cream were incorporated and mixed for 3 min. To this mixture, the previously sieved dry ingredients were added and mixed well for further 3 min. Then dough was prepared using desired amount of potable water till a needed consistency was attained, which took 6-7 min of kneading.

***Sheeting:*** Using a metal roller, the dough was made into form of sheet of thickness about 4 mm.

***Cutting:*** The sheeted dough was cut into circular pieces using metallic mould of 40mm diameter. The dough pieces so shaped were carefully placed in an aluminium tray for further baking process.

***Baking:*** The tray containing the circular pieces of dough was kept in a baking oven (M/s Dolar Equipment Pvt Ltd., Bangalore) which was already maintained at 165°C, for 25 min. After baking, the tray was taken out and allowed for spontaneous cooling to room temperature.

***Packing:*** The oat incorporated biscuits thus prepared were packaged in metalized polyester pouches and stored at room temperature until further use for analysis.

# Effect of incorporation of oat on dough texture and biscuit quality

Use of oat powder in biscuit formulation would alter the properties of dough and thereby biscuit properties. These alterations in properties were recorded by replacing the refined wheat flour at refined wheat flour : oat ratios of 75:25; 65:35 and 55:45 by weight. Dough was prepared

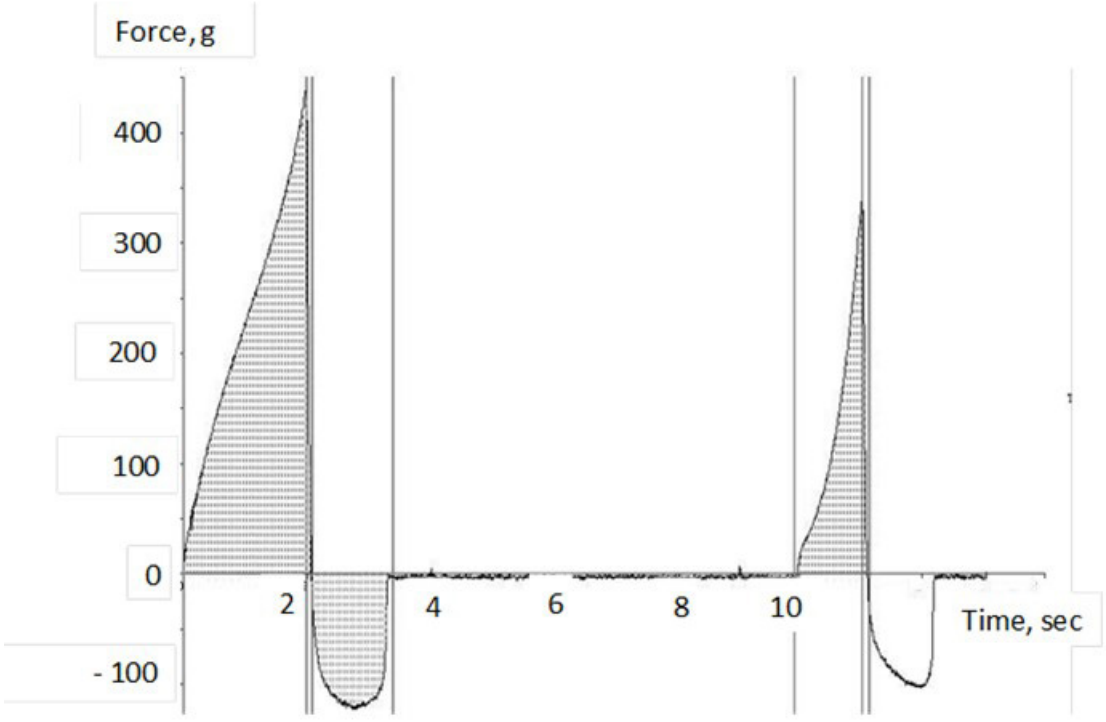
from these mixtures as described above and the properties measured for optimization.

# Analyses

## Textural properties of dough

Texture Profile Analysis is a useful technique for measuring textural characteristics. Several workers employed this technique to measure rheological characters of dough[15,16,17]. In this study also, texture analyser was used to measure the textural characteristics of biscuit dough. First dough was tempered to 30°C and then flattened to a sheet form and carefully cut to get cubes of ~ 2.0 cm size. These were used to measure various rheological parameters with the help of Texture Analyser (A TA.XT plus-Stable Micro System, England) by adopting the two-bite 'texture profile analysis' (TPA) method of Peleg (1976)[18] and Bourne (1978) [19]. The measurement settings were: P/75 probe, 7.5 cm dia; load cell, 50 kg, pre-test speed: 1 mm/s, test speed: 2 mm/s, target mode: distance; distance of probe travel: 10 mm, data acquisition rate, 400 pps. The following properties were measured with the help of Texture Exponent 32 software: hardness, adhesiveness, springiness, cohesiveness and gumminess. The texture profile (force vs. time) curve obtained during the performance of test was used for computation of all the TPA parameters (Fig. 1). The maximum force shown on the first peak was taken as hardness. The area of first negative peak was considered as adhesiveness, and cohesiveness (dimensionless) was defined as the ratio between positive area of 2nd and 1st peaks. Springiness was measured as the ratio between time difference of 2nd and 1st cycle which is dimensionless. Gumminess was obtained by multiplying hardness and cohesiveness values (g).

Most of the studies on rheology of dough reported in literature were conducted using rheometer, however some workers used texture analyser also for studying viscoelastic characteristics[20]. In this study also, texture analyser was employed to measure viscoelastic properties namely, stress relaxation time, modulus of elasticity and coefficient of viscosity. In this test, the sample specimen was compressed by texture analyser probe (p/75) to 25% of original height and this compression was maintained constant throughout the test period. This was done by the procedure suggested by Rao and Steffe (1992)[21] and adapted by Dwarakanath et al. (2013)[22].




H = Hardness =Maximum value on first peak (Newtons); Cohesiveness= Area of second peak / Area of first peak = A2 / A1; A3 = Adhesiveness = Area of negative peak (N.sec); Adhesive Force = Ad.F. = Maximum value on first negative peak (Newtons); Springiness = Time difference between C& D / Time difference between A&B; Gumminess = Hardness x Cohesiveness (Newtons); Chewiness = Gumminess x Springiness (Newtons)

**Fig. 1:** Texture Profile Analysis curve

## Subjective analysis of biscuits (sensory evaluation)

The oat incorporated biscuits thus prepared were subjected to subjective analysis i.e. sensory evaluation at room temperature. The sensory evaluation was done by a panel of ten judges. The panel of judges were asked to carry out evaluation of biscuits and record their liking on 9-point Hedonic scale for the parameters namely colour and appearance, flavour, body and texture and overall acceptance. On Hedonic scale, 'like extremely' had a score of 9 and a score of 1 indicated 'dislike extremely'[23]. The sensory analysis sessions were done in the sensory evaluation room of the Institute.

## Instrumental hardness of biscuits

The instrumental settings for measuring hardness of oat incorporated biscuits employing texture analyser were: test speed: 2mm/s, distance: 5mm, and data acquisition rate : 400pps. Test was carried out using Texture Analyser employing Warner Bratzler blade and Slotted Insert (HDP/BS) module. The biscuit sample of 40 ± 3 mm in diameter and 6±0.3mm in thickness was placed centrally over the Slotted Insert (HDP/BS) and Warner Bratzler blade was allowed to cut the biscuit sample through the slot till the biscuit was divided into two major pieces. This process created a force-time plot on the computer monitor linked to the instrument (Fig.2). Though the crispy nature of biscuit was responsible for creation of many peaks, the maximum force on the plot was taken as hardness of the biscuit. Other workers also employed Texture Analyser for evaluation of biscuit quality[24,25].

## Chemical composition

The sample of biscuits for chemical analysis was prepared by placing biscuit pieces in a grinder and shearing into a uniform powder. Moisture in the sample was estimated by gravimetric method[26] and crude fat was determined by Soxhlet method[26]. Known amount sample was acid digested, from which total protein was estimated by standard Micro Kjeldahl method[27] using Kjel plus digestion & distillation assembly (Di SWI-M, KPS-006R, Pelican Instruments, Chennai)], but total ash and acid insoluble ash were determined by Direct method[26]. Difference between the weight of above constituents and total sample weight indicated total carbohydrates content. In order to measure β- glucan content of ground biscuit sample, McCLEARY method using β-glucan estimation kit (Megazyme International Ireland Ltd., Marketed by: Pro Lab Marketing Pvt. Ltd. New Delhi, India) was adopted.

## Physical characteristics

The following physical characteristics were determined: thickness and diameter of moulded dough and biscuits by an mm-scale. Spread ratio of biscuits is the ratio of weight to thickness of the biscuits[13]. For this purpose, weight of biscuits was determined using a digital weighing balance (0.1 g accuracy) (Spark Brand, Bangalore) and spread ratio determined as above.

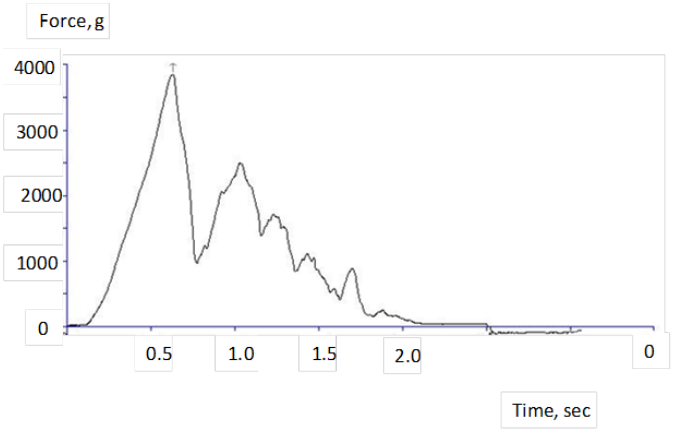



**Fig. 2:** Force-time curves of biscuit by Texture Analyzer

Water activity ($a_w$) is the ratio of vapour pressure over a food sample to that over pure water. This was indirectly measured by the change in dielectric property of sensor when exposed to different humidities. Based on this principle, $a_w$ was determined using an $A_w$ - meter (Rotronic Hygroskop, BT-RS1 Ag Switzerland). The biscuit powder was taken in a plastic dish which was specific to the instrument, up to the mark indicated, and the dish filled with the sample was placed in the dish holder of the instrument. The probe assembly was kept in the groove over the dish holder so that it formed a small empty chamber over the sample. Vapour from the sample slowly filled the chamber and got equilibrated at a humidity depending on the $a_w$ of sample. A fan button was put on to hasten the equilibration process. Water activity, which is the function of change in capacitance of the sensor to change in equilibrium humidity in space surrounding over the biscuit sample, was directly read on the monitor.

## Statistical analysis of results

The sensory evaluation data of the effect of oats incorporation were statistically analysed by one way ANOVA by SPSS package (15.0 Windows Evaluation Version). Three replications were conducted for all the treatments.

## Results and discussion

The rolled oats were ground and the ground oats were used to replace maida (refined wheat flour) in biscuit formulation at three levels viz. 25, 35 and 45%. The upper limit of oats incorporation was determined by preliminary trials in which it was observed that beyond 45% level of incorporation it was difficult to prepare optimum quality dough. Hence, the effect of incorporation of oats was studied on the dough quality below 45% levels and then its effect on biscuit quality was studied.

## Effect of incorporation of oats on dough rheology

Dough rheology is very important because it has profound influence on biscuit quality. When we squeeze and work the dough and leave, it will relax and recovers part of strain it has been subjected to, because dough is a viscoelastic material possessing flow as well as elastic properties. The viscoelastic nature of dough was studied by a number of workers[28, 29,30]. During mixing of maida and water, the maida starch absorbs water and swells becoming sticky and very cohesive. The dough formation takes place by water absorption by starch particles aided by gluten development[14]. The water absorption property of gluten may be affected by additives used in dough making which includes oats in the present project. Hence, the dough quality was studied by Texture Analyzer by Texture Profile Analysis technique as well as estimation of viscoelastic characteristics.

Hardness of the dough decreased from 25.05 to 21.73 N for the 0 and 25% oats incorporated dough and thereafter there was not much change in hardness (Table-1). It means that dough became softer by addition of the oats at 25% level, but at higher level, it did not have much effect. Adhesiveness of the dough increased from 63. 45 to 119.35 N sec for 0 and 25% oats level but as oats level increased adhesiveness was reduced to 100.33 and 96.68 N sec for the 35 and 45% oats level. Cohesiveness increased from 0.13 to 0.16 and springiness from 0.16 to 0.24. However, for the 35 and 45% oats level these attributes decreased. Gumminess value for dough without oats was 3.28 N which decreased to 2.62 and 2.84 N for 35 and 45% oats containing dough. The decrease in hardness by oats incorporation may be attributed to the interaction between polysaccharides and proteins from wheat flour as reported by Jones and Erlander (1967) [31]. Sudha et al. (2007)[13] observed that dough strength decreased significantly from 8.5 to 4 and 7.0 to 3.5 min (measured by farinograph) in the case of dough incorporated with oat and barley. Their results showed weakening of the dough with the increasing level of oat bran. Similar result was obtained in this study for 25% oats incorporation. Incorporation of millets into dough was done by other workers like, finger millet[32,33], multigrain[34] and oats[35]. The adhesive and cohesive property of oat flour is attributed to the presence of β –glucan. Wheat has β-glucan content of 0.18 – 1.8%[36] and oats has 2.3–8.5 %[12]. Wheat prolamin proteins, gliadin and glutenin, make up approximately 80% of the seed storage proteins and are responsible for formation of the gluten network that imparts the unique properties of wheat dough. During mixing, the gluten network forms, endowing the dough with viscoelasticity and gas holding capacity, which is essential for production of baked products.

However, utilization of oats in baked products is limited due to the inability of oat flour to form cohesive, viscoelastic dough, such as the gluten network of wheat dough[37].

The viscoelastic properties of the dough were also recorded. Stress relaxation time is defined as the time required for the stress to be relaxed to a value equal to 36.7 % of the stress applied on sample, in a stress relaxation test[21]. Modulus of elasticity (ME) is the value equal to the value of stress/strain and represents solid character in a material[38]. Stress relaxation time ($\tau_o$) for the 0% oats was 0.402 sec. As shown in Table-1, as oats level increased stress relaxation time slightly increased to 0.422 and 0.449 sec for 25 and 45% oats containing dough. The Et for control was 10408 Pa which increased to 11448, 12520 and 12871Pa, respectively for 25, 35 and 45% oats containing dough respectively. The same trend has appeared in the viscosity character of the dough. The viscosity coefficient values were 37323 Pa for control and 39435, 40267 and 43685 Pa, respectively for 25, 35 and 45% oats containing dough. Since modulus of elasticity represents that elastic character[38], it can be inferred that solid character of the dough also increased by oats incorporation. This was corroborated by longer stress relaxation times. $\tau_o$ of dough was also measured by other workers to characterize viscoelasticity. $\tau_o$ of 4 sec for wheat flour dough[39], 0.33 – 0.41 sec[40] and 10.62-10.66 sec[41] also for wheat flour dough were reported, the second one being similar to the values obtained in the present study. ME was also measured by other workers. They obtained ME of dough as $6.70\times10^4$Pa - $11.96\times10^3$ Pa which is similar to the values obtained in the present study. Coefficient of viscosity values of dough as measured by Yang et al. (2023) [41] were $7.14\times10^5$ Pa·s and $9.31\times10^5$ Pa·s which are much higher than the values obtained in this study. On the other hand, RGM Van der Sman (2021)[42] reported values of 1000 – 5000 Pa.s in biscuit dough at 20 – 40°C, which are much lower than

the ones obtained in this study. This may be attributed to various factors including the instrumental conditions employed to measure the rheological parameters. Many authors have shown that a slower relaxation time is associated with good baking quality[43,44,45]. Stress relaxation measurements on dough and gluten showed that the relaxation behaviour of dough could be described by two relaxation processes[46]: a rapid relaxation over 0.1–10 s and a slower process occurring over 10–10,000 s. The rapid relaxation process has been associated with small polymer molecules which relax rapidly, and the longer relaxation time has been linked to the HMW polymers found within gluten. In case of wheat – oat dough used in the present study, the relaxation could be termed as rapid, the stress relaxation time being 0.402 – 0.449 sec.

## Effect of incorporation of oats on biscuit quality

The effect of incorporation of oats on biscuit was evaluated by sensory analysis. The biscuits containing 25, 35 and 45% oats were subjected to sensory evaluation and the scores are presented in Table-2**.** The colour and appearance score for biscuits with 0% oats level (control) was 8.05 and with 25% oats was 8.02, while that for biscuits with 35% oats decreased to 7.70. The scores for colour and appearance decreased but statistically no difference was observed from 0 to 35% oats level. The increase in oats level to 45% resulted in browner colour securing a lower score of 7.44, which was statistically different from 0% but same as 35% oat biscuits. Similar observation of darkening of colour was made by Sudha et al. (2007)[13] in case of biscuits made by incorporation of oat bran, but use of barley bran resulted in only marginal variation. Similar trend of biscuits becoming darker on oats incorporation was also observed in the present study.

With regard to flavor, the biscuits with 0% oats level scored a flavour score of 7.43 due to mild, normal biscuit flavour. The score improved to 7.82 for the biscuits with 25% oats and the sample had pleasant flavour. The score reduced to 7.70 and 7.34 for the biscuits with 35 and 45% oats due to increased cooked flavor and dry mouthfeel. Heat induced reactions of precursors present in the oat groat are primarily responsible for the development of oat flavour during its normal processing into commercial food products[47]. This may be cited as the reason for higher flavor score of biscuits made from 25% oats containing dough. In cookies containing 10–30% oat glucan containing mixture, the cereal/grain flavor intensity was only significantly different than the control at the 30% level of flour replacement[48].

The body and texture score for biscuits with 0% oats was 7.90. The product was crispy and softer. The score decreased to 7.88 when the oats level in biscuits was increased to 25%. The biscuits had slightly hard body; the score reduced to 7.28 for the biscuits with 35% oats and 7.08 for 45% oats a due to hard body. Thus it was observed that as oats level increased, the biscuit became harder. It was reported by other workers that oats incorporation also rendered biscuits harder and also imparted dry mouthfeel[49]; similar observation was also made in the present study. On this basis, Sudha et al. (2007)[13] reported that 30% oats bran incorporation was highly acceptable in biscuits. In our study, overall acceptance scores of control, 25, 35 and 45% oats level biscuits were 8.00, 7.90, 7.32 and 7.27, respectively (Table-2). It may be noticed that increasing oats level decreased the overall acceptance score but the decrease in score was significant only at higher than 25% oats incorporation. ANOVA presented in Table-3 showed the significant effect of oats incorporation on all the sensory attributes of biscuit which was above 25% level of significance. In their study, Sudha et al. (2007)[13]

**Table 1:** Effect of incorporation of oats on dough rheology 300 C

| Textural parameter | Oats level in biscuit formulation | | | |
|---|---|---|---|---|
| | **0 % oats** | **25 % oats** | **35 % oats** | **45 % oats** |
| Hardmess (N) | 25.05±1.4 | 21.73±1.25 | 20.37±0.49 | 21.76±0.32 |
| Adhesiveness (N Sec) | 63.45±18.1 | 119.35±8.07 | 100.33±2.25 | 96.68±8.85 |
| Cohesiveness | 0.13±0.01 | 0.16±0.00 | 0.13±0.00 | 0.13±0.01 |
| Springiness | 0.16±0.01 | 0.24±0.01 | 0.19±0.01 | 0.19±0.01 |
| Gumminess (N) | 3.28±0.18 | 3.39±0.20 | 2.62±0.05 | 2.84±0.14 |
| Stress relaxation time, $\tau_o$ (Sec) | 0.402±0.01 | 0.422±0.02 | 0.424±0.01 | 0.449±0.006 |
| $E_t$ (Pa) | 10408±425 | 11448±694 | 12520±213 | 12871±491 |
| Coefficient of viscosity, $\eta=\tau_o*E_o$ (Pa.s) | 37323±1468 | 39435±3827 | 40267±1507 | 43685±1733 |

**Note:** $E_t$ = Total modulus of elasticity of dough during stress relaxation test; $E_o$ = Initial modulus of elasticity of dough during stress relaxation test

reported that highly acceptable biscuits could be obtained by incorporating 30% of oat bran in biscuit formulation.

# Physico- chemical characteristics of cheese incorporated oat biscuit

## Chemical composition

Table-4 shows chemical composition of biscuits. It may be observed that the β- glucan content was 0.70 in oat incorporated biscuit. Biscuits had moisture 2.94%, crude fat 24.23%, protein 8.52%, carbohydrate 62.28%, ash 2.03% and acid insoluble ash 0.18%. Youssef et al. (2016) [50] reported moisture 4.63 – 4.98%, crude fat 16.12 – 18.39%, protein 6.06 – 7.8%, carbohydrate 71.31 – 75.9% and ash 1.31-1.59% in biscuit made from oat incorporated dough. Crude fibre including β– glucan was 0.61-0.91%. These values slightly vary from the results of the present study because of higher baking temperature and short duration (180ºC/6 min) and use of whole wheat flour in their study.

## Physical properties

Physical properties of biscuits are presented in Table-4. The hardness of biscuits was 76.18 N, diameter 38.3 mm, thickness 6 mm, ave weight 8.59 g and spread ratio as 6.52. Higher spread value means that during baking the dough spreading was more. Sudha et al. (2007)[13] reported that the spread ratios for 10, 20, 30 and 40% oat bran incorporations were 7.6, 8.3, 8.18 and 8.24 respectively. Youssef et al. (2016)[50] reported spread ratio of 9.42 – 10.21 for oat incorporated biscuit and stated that use of oats increased the spread ratio. Regarding hardness value, Choudhury et al. (2015)[51] reported a value of 54.2N for normal biscuit as measured by texture analyser. In this study, higher value of 76.18 N was obtained which could be attributed to incorporation of 25% oats in the dough.

Water activity ($a_w$) of biscuits generally ranges from 0.1 to 0.23[52]. Freshly baked biscuits usually have water activity of about 0.3[53]. Water activity is an important attribute because it was found that biscuits lose crispness at about 0.5 and more[54]. Hence, crispness of biscuits is highly related to water activity. Water activity and mois-

**Table 2:** Effect of oats level on sensory qualities of biscuits

| Oats level in biscuit formulation (%) | Colour & appearance (CA) | Flavour (FL) | Body & texture (BT) | Overall acceptance (OA) |
|---|---|---|---|---|
| 0 | $8.05 \pm 0.07^{b}$ | $7.43 \pm 0.07^{ab}$ | $7.90 \pm 0.06^{b}$ | $8.00 \pm 0.06^{b}$ |
| 25 | $8.02 \pm 0.08^{b}$ | $7.82 \pm 0.13^{b}$ | $7.88 \pm 0.10^{b}$ | $7.90 \pm 0.09^{b}$ |
| 35 | $7.70 \pm 0.10^{ab}$ | $7.70 \pm 0.09^{ab}$ | $7.28 \pm 0.08^{a}$ | $7.32 \pm 0.09^{a}$ |
| 45 | $7.44 \pm 0.12^{a}$ | $7.34 \pm 0.10^{a}$ | $7.08 \pm 0.10^{a}$ | $7.27 \pm 0.10^{a}$ |

Note: Values with different superscripts in a column are significantly different from each other ($p<0.05$)

**Table 3:** ANOVA for effect of oats level on sensory qualities of biscuits

| Source | df | CA | | FL | | BT | | OA | |
|---|---|---|---|---|---|---|---|---|---|
| | | MSS | F | MSS | F | MSS | F | MSS | F |
| Oats level | 3 | 0.504 | 9.288* | 0.295 | 4.914* | 1.047 | 23.313* | 0.879 | 20.409* |
| Error | 20 | 0.054 | | 0.060 | | 0.045 | | 0.043 | |
| Total | | | | | 23 | | | | |

*Significant at $p<0.05$

**Table 4:** Proximate chemical composition and physical characteristics of the oat incorporated biscuits

| Chemical composition | | Physical properties | |
|---|---|---|---|
| Constituents (%) | Value | Parameters | Value |
| Moisture | 2.94 | Hardness (N) | 76.18 ± 11.83 |
| Crude fat | 24.23 | Diameter (mm) | 38.30 ± 0.3 |
| Protein | 8.52 | Thickness (mm) | 6.00 ± 0.58 |
| Carbohydrate | 62.28 | Weight (g) | 8.59 ± 0.01 |
| Ash | 2.03 | Spread ratio | 6.52 ± 0.7 |
| Acid insoluble ash | 0.18 | | |

ture contents are always important parameters influencing stability of biscuits during storage, in particular the resistance against microbes and rheological properties of the products. In food industry, foods with an $a_w$ <0.60 are considered as microbiologically stable, although some of their constituents may undergo chemical reactions. Being products with a long shelf life, biscuits are usually stored at room temperature (21–40 °C). The quality of biscuits is lost by changes in sensory properties such as crispiness, hardness, colour and flavour, all of which are correlated with water activity[55]. The commercial shelf life of the biscuits ranges from 3 to 6 months[4]. In the present study shelf life of 90 days at 30°C was observed.

## Conclusion

It was concluded that good quality biscuits could be prepared by incorporating 25% oats into biscuit dough.

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