# Effect of Taro (*Colocasia esculenta*) Starch-Hydrocolloids Mixture on the Physical and Sensory Characteristics of Leavened Bread

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**Abstract:** During this study, different blends of taro starch-hydrocolloid were incorporated in yeast leavened bread and their effects were investigated. The specific volume, moisture content and slice shape of the bread were found to be improved by the addition of taro starch-guar gum blend. Taro starch-xanthan gum mixture was also found to be a good additive to improve specific volume, slice shape, crumb softness as well as sensory characteristics of bread. The study reveals taro starch-hydrocolloid blend can be utilized as a novel ingredient to improve the physical and sensory characteristics of leavened bread.

**Keywords:** Taro starch, Hydrocolloids, Bread, Physical Properties, Sensory Properties.

## INTRODUCTION

Taro (*Colocasia esculenta*) is a tuber crop grown in humid tropical and subtropical regions of the world including Pakistan. It is a good source of starch having some novel functional characteristics as compared to other commercial starches. Taro starch granule varies from 1 to 6.5 μm which is about one-tenth that of the potato starch. Taro starch produces clarity to the suspension even at higher solid concentrations. It also has high swelling power, high gel strength and peak viscosity and forms hard coatings [1-4]. In addition, taro has been used in baby foods, taro chips, taro bread [5-6] and taro sorbet [7]. Smaller granular starch has been demonstrated to be good filler for biodegradable plastic films [8] and has also been suggested to provide a better mouth feeling as a lipid substitute [9-10].

In recent times, there has been a great interest in studying the properties of mixture of various hydrocolloids with different native starches and resultant blends are considered to be important ingredients in the modern health-conscious food industries. Hydrocolloids influence the functional, pasting, textural and rheological properties of native starches. It has been extensively reported that the addition of hydrocolloids to starch suspensions causes a synergistic increase in viscosity and significantly improves the inherent characteristics of native starch [11-16]. Hydrocolloids are widely used in starch-based food products to attain better heating or cooling stability, improved texture, moisture and oil retention, and to develop good quality end products [17-20, 14].

Numerous investigations have been carried out showing the effective role of hydrocolloids in the bread industry. An improvement in wheat dough stability during proofing can be obtained by the addition of hydrocolloids [11]. A similar study with locust bean, xanthan gum and alginate discovered a softening effect of those hydrocolloids on bread texture [21].

The present study was carried out to examine the effects of taro starch-hydrocolloids mixtures as an additive and evaluate its impact on the physical and sensory characteristics of yeast leavened bread.

## MATERIALS AND MTEHODS

Four different hydrocolloids i.e. gum arabic, CMC, guar and xanthan gums were selected. All the hydrocolloids used were of food grade, chemicals were of analytical grade and purchased from Sigma Co. St. Louis, MO., USA. Taro (*Colocasia esculenta*) was purchased from local market of Karachi, Pakistan and its starch was isolated using freeze-thaw method [22].

### Bread Making Process

Commercial hard wheat flour with 13.4 % protein content, 14 % moisture and 0.7 % ash content was used in the process of bread making. A basic dough recipe described by Guarda *et al*. [23] was used with some modifications. It consisted of 100 g wheat flour, 2 g yeast, 2 g salt and sufficient amount of water. In taro starch-hydrocolloids containing bread, three different concentrations of hydrocolloids (0.2, 0.4 and 0.6 % on flour basis, w/w) and 2 % taro starch were added to the dough. All the ingredients were uniformly mixed for 20 minutes in a dough mixer and dough was subsequently fermented for two hours. at 30 $^{o}$C. The dough was

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hand punched, mechanically sheeted and then rolled. Proofing was performed at 30 $^{o}$C and 85 % relative humidity for 45 min in tin pans. The bread was baked in an electric oven for 25 min at 200 $^{o}$C. Bread loaves were cooled down at 25 $^{o}$C and 85 % relative humidity for two hours and then packed in polythene bag.

### Physical Properties of Bread

Different physical parameters of bread (both control and with taro starch-hydrocolloids mixtures) including weight, moisture, volume, specific volume and width/height ratio of the central slice were investigated. Moisture content was evaluated by taking the reduction in weight of bread slice after drying for 4hrs at 105 $^{o}$C. Loaf volume was determined by displacement of rapeseed according to method of Sahin and Gulum [24] while the change in bread volume was evaluated by calculating the specific volume. The shape of loaf was investigated by measuring width/height ratio of the central piece of loaf. Crumb firmness was determined by using Universal Testing Machine (Zwick GmbH & Co., Germany). The crosshead of the UTM fitted with a 25 mm diameter plunger, driven down at a speed of 1 mm/s and compressed a 25 mm thick slice to a depth of 80 %. The speed of crosshead was adjusted to 1 mm/s. The peak of the compression curve considered the resistance of the crumb to the compression and represented the crumb firmness.

### Sensory Properties of Bread

Sensory analysis of prepared breads was carried out by a panel of 10 judges, using a hedonic scale scoring 1 (dislike extremely) to 5 (like extremely). The judges included the teachers and research students of the Department of Food Science and Technology, University of Karachi. The quality attributes evaluated were visual appearance, taste, aroma and crumb softness. The score received from panel was averaged for each attribute. The overall acceptability of bread was calculated by taking the weighted arithmetic mean, given the following weightage to each attribute: Visual appearance 35%, Taste 15 %, Aroma 15 % and Crumb softness 35 %.

### Statistical Analysis

All measurements were analyzed in triplicate for each sample and results were expressed as means ± standard deviations. A one-way analysis of variance (ANOVA) was applied to find the significance of differences between the mean values at $P < 0.05$ level of confidence. The statistical analyses were performed using SPSS version 17.01 for windows program (SPSS Inc., Chicago, IL, USA).

## RESULTS

### Physical Properties

The effect of different mixture of taro starch with different hydrocolloids on the physical quality attributes of bread is presented in Tables **1a-1c**. The specific volume of bread considerably enhanced with the addition of both TSG (Taro starch-guar gum) and TSX (Taro starch-xanthan gum) mixtures. On the contrary, a reduction was observed when TSA was incorporated. Data indicated that TSC (Taro starch-CMC) had no effect on specific volume index. A significant effect was obtained by TSG followed by TSX alongwith taro starch. Noteworthy was the improvement in specific volume of bread at even the least hydrocolloid concentration i.e. TSG2 (Taro starch-0.4 % guar) & TSX2 (Taro starch-0.4 xanthan). At relatively high gum concentration (0.4 % and 0.6 %), only slight improvement was recorded. The data indicated that moisture content of the bread crumb was increased by the addition of different hydrocolloid-taro starch mixture particularly TSG3 (Taro starch-0.6 % guar) which gave the highest value as compared to other samples. The addition of TSG and somewhat TSX reduced the width/height ratio of bread. The effect was more pronounced for TSG3 (Taro starch-0.6 % guar). However, the addition of TSC merely reduced the

**Table 1a: Effect of Hydrocolloids (0.2 %) and Taro Starch (2 %) on the Physical Properties of Bread**

| Sample | Loaf weight (g) | Loaf volume (cm$^3$) | Specific volume (cm$^3$/g) | Crumb moisture (%) | Width/height ratio |
|---|---|---|---|---|---|
| TS | 145.8 ± 2.3$^a$ | 352.8 ± 3.5$^a$ | 2.42 ± 0.2$^a$ | 38.7 ± 0.3$^a$ | 1.55 ± 0.2$^a$ |
| TSA1 | 146.2 ± 1.7$^a$ | 343.6 ± 3.8$^a$ | 2.35 ± 0.3$^a$ | 38.8 ± 0.4$^a$ | 1.62 ± 0.3$^a$ |
| TSC1 | 142.6 ± 2.0$^a$ | 350.8 ± 4.4$^a$ | 2.46 ± 0.2$^a$ | 39.0 ± 0.6$^a$ | 1.50 ± 0.2$^b$ |
| TSG1 | 134.0 ± 1.4$^b$ | 388.6 ± 4.2$^b$ | 2.97 ± 0.3$^b$ | 39.0 ± 0.4$^a$ | 1.38 ± 0.1$^c$ |
| TSX1 | 148.5 ± 2.6$^a$ | 400.9 ± 5.2$^b$ | 2.76 ± 0.4 $^c$ | 40.4 ± 0.5b | 1.46 ± 0.2$^c$ |

Values are means ± SD of triplicates.
Values in the same column with different superscript are significantly different (*P < 0.05*).

**Table 1b: Effect of Hydrocolloids (0.4 %) and Taro Starch (2 %) on the Physical Properties of Bread**

| Sample | Loaf weight (g) | Loaf volume (cm$^3$) | Specific volume (cm$^3$/g) | Crumb moisture (%) | Width/height ratio |
|---|---|---|---|---|---|
| TS | 145.8 ± 2.3$^{a}$ | 352.8 ± 3.5$^{a}$ | 2.42 ± 0.2$^{a}$ | 38.7 ± 0.3$^{a}$ | 1.55 ± 0.2$^{a}$ |
| TSA2 | 138.3 ± 5.4$^{b}$ | 311.2 ± 7.8$^{b}$ | 2.25 ± 0.1$^{a}$ | 39.3 ± 0.4$^{a}$ | 1.60 ± 0.1$^{a}$ |
| TSC2 | 145.0 ± 4.2$^{a}$ | 368.3 ± 8.2$^{a}$ | 2.54 ± 0.3$^{a}$ | 39.4 ± 0.2$^{a}$ | 1.44 ± 0.2$^{a}$ |
| TSG2 | 148.7 ± 4.8$^{a}$ | 463.9 ± 6.5$^{c}$ | 3.10 ± 0.2$^{b}$ | 39.2 ± 0.2$^{a}$ | 1.28 ± 0.2$^{b}$ |
| TSX2 | 142.3 ± 5.3$^{a}$ | 394.2 ± 7.1$^{d}$ | 2.79 ± 0.3$^{c}$ | 40.8 ± 0.3b | 1.40 ± 0.1$^{a}$ |

Values are means ± SD of triplicates.
Values in the same column with different superscript are significantly different ($P < 0.05$).

**Table 1c: Effect of Hydrocolloids (0.6 %) and Taro Starch (2 %) on the Physical Properties of Bread**

| Sample | Loaf weight (g) | Loaf volume (cm$^3$) | Specific volume (cm$^3$/g) | Crumb moisture (%) | Width/height ratio |
|---|---|---|---|---|---|
| TS | 145.8 ± 2.3$^{a}$ | 352.8 ± 3.5$^{a}$ | 2.42 ± 0.2$^{a}$ | 38.7 ± 0.3$^{a}$ | 1.55 ± 0.2$^{a}$ |
| TSA3 | 151.3 ± 5.4$^{a}$ | 335.9 ± 8.2$^{b}$ | 2.22 ± 0.1$^{a}$ | 39.5 ± 0.5$^{b}$ | 1.64 ± 0.1$^{a}$ |
| TSC3 | 153.9 ± 5.8$^{a}$ | 397.1 ± 7.1$^{c}$ | 2.58 ± 0.3$^{b}$ | 39.7 ± 0.2$^{b}$ | 1.40 ± 0.1$^{b}$ |
| TSG3 | 152.4 ± 4.3$^{a}$ | 469.4 ± 5.4$^{d}$ | 3.12 ± 0.2$^{c}$ | 39.8 ± 0.3$^{b}$ | 1.34 ± 0.2$^{b}$ |
| TSX3 | 154.2 ± 4.8$^{a}$ | 441.0 ± 6.0$^{d}$ | 2.84 ± 0.1$^{d}$ | 41.2 ± 0.2$^{c}$ | 1.38± 0.1$^{b}$ |

Values are means ± SD of triplicates.
Values in the same column with different superscript are significantly different ($P < 0.05$).

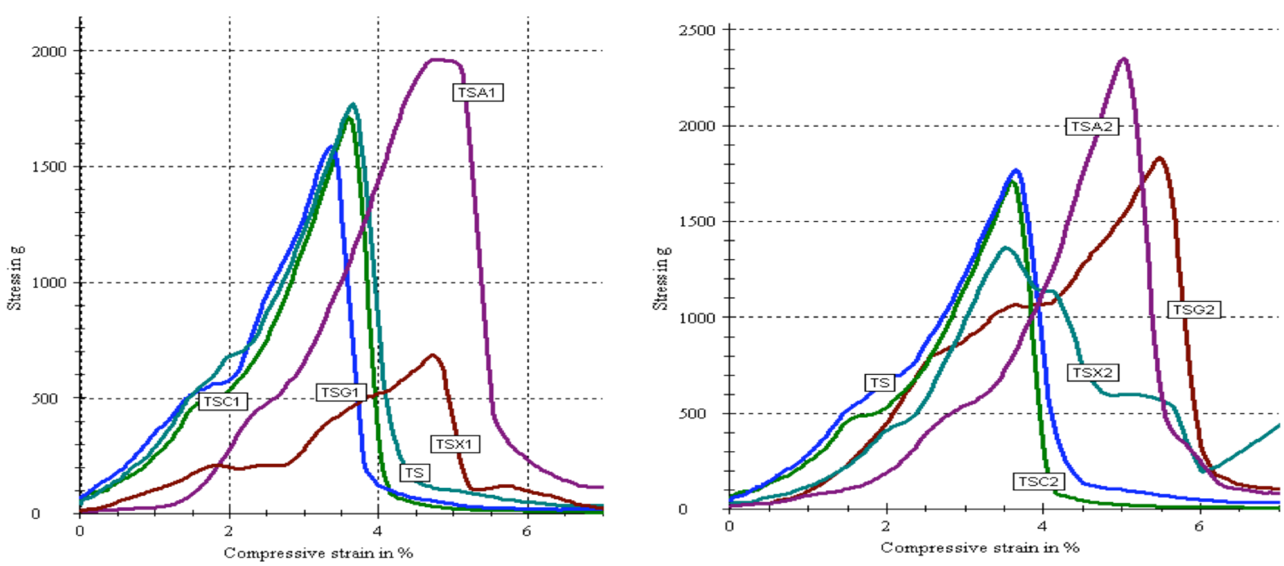
width/height. On the other hand, TSA (Taro starch-arabic gum) increased in the width/height ratio as compared to control.

### Crumb Firmness

The crumb firmness analysis of bread with or without taro starch-hydrocolloid blends measured by Universal Testing Machine was displayed in Figures **1a-1c**. Both TSG and TSX showed a considerable reduction in crumb hardness especially for TSG2 & TSX2 (i.e. at 0.2 % gum concentration). TSC did not significantly affect the bread crumb hardness at all gum concentrations. On the contrary, TSA enhanced the hardness of the bread crumb as compared to control.

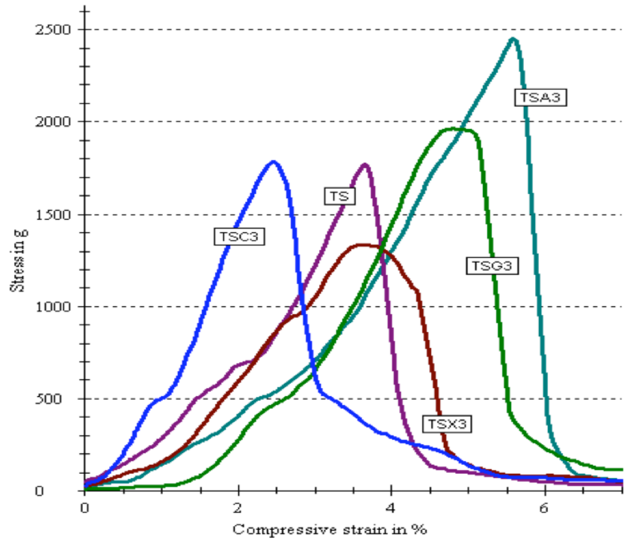
### Sensory Evaluation

For sensory evaluation of bread, five points hedonic scale was used. All the sensory parameters received




**a** **b**

**(Figure 1). continued**




**c**

**Figure 1a:** Effect of hydrocolloids (0.2 %) and taro starch (2 %) on bread crumb firmness obtained by UTM.

**b:** Effect of hydrocolloids (0.4 %) and taro starch (2 %) on bread crumb firmness obtained by UTM.

**c:** Effect of hydrocolloids (0.6 %) and Taro starch (2 %) on bread crumb firmness obtained by UTM.

scores higher than 3 in all the bread samples (Tables **2a-2c**). Both TSG and TSX improved the appearance compared to TSC and TSA. The data indicated that addition of TSG2 received the maximum score while TSC had no effect on bread appearance. However, bread with TSA gave the smallest score, being even worst for TSA3 (Taro starch- 0.6 % gum Arabic). It was observed that all taro starch-hydrocolloid blends had no effect on the taste of bread at 0.2 and 0.4 % gum concentration. However, TSG3 and TSA3 (Taro starch- 0.6% arabic gum) reduced the taste score significantly. No change was observed in aroma by incorporating taro starch-hydrocolloids blends except TSC. Only a slight improvement was observed with TSC2 (Taro starch- 0.4 % CMC) suggesting that hydrocolloids do not affect the aroma of bread. All taro starch-hydrocolloid blends, except TSA, produced higher scores regarding crumb softness when compared with the control. It was noteworthy that maximum softness was obtained at low gum concentration and it reduced by increasing the gum concentration.

## DISCUSSION

### Physical Properties

Different physical parameters of bread were significantly affected by the addition of hydrocolloids along with taro starch. The addition of both TSG and TSX considerably improved the specific volume of bread. Similar finding has been reported by Rosell *et al*. [11] and Ribotta *et al*. [25] for guar and xanthan gum. However, a reduction in specific volume was observed by the addition of TSA in bread formulation. It

**Table 2a: Influence of Hydrocolloids (0.2 %) and Taro Starch (2 %) on the Sensory Characteristics of Bread**

| Sample | Visual Appearance | Taste | Aroma | Crumb Softness | Overall* Acceptability |
|---|---|---|---|---|---|
| TS | 4.00 ± 0.2$^{a}$ | 3.72 ± 0.3$^{a}$ | 4.11 ± 0.3$^{a}$ | 3.17 ± 0.2$^{a}$ | 3.68 ± 0.2$^{a}$ |
| TSA1 | 3.54 ± 0.1$^{b}$ | 3.70 ± 0.2$^{a}$ | 4.15 ± 0.3$^{a}$ | 3.00 ± 0.2$^{a}$ | 3.32 ± 0.2$^{b}$ |
| TSC1 | 3.95 ± 0.2$^{c}$ | 3.75 ± 0.1$^{a}$ | 4.26 ± 0.2$^{b}$ | 3.35 ± 0.1$^{b}$ | 3.72 ± 0.3$^{a}$ |
| TSG1 | 4.34 ± 0.2$^{d}$ | 3.78 ± 0.3$^{a}$ | 4.15 ± 0.4$^{a}$ | 3.90 ± 0.3$^{c}$ | 4.12 ± 0.1$^{c}$ |
| TSX1 | 4.25 ± 0.3$^{d}$ | 3.68 ± 0.2$^{a}$ | 3.98 ± 0.2$^{c}$ | 3.70 ± 0.2$^{c}$ | 3.90 ± 0.2$^{d}$ |

Five point hedonic scale ratings: 5 = like extremely and 1 = dislike extremely.

*Overall acceptability was calculated by weighted arithmetic mean, given the following weight to each attribute: Visual appearance 35%, Taste 15%, Aroma 15% and Crumb softness 35%.

Values are means ± SD of triplicates.

Values in the same column with different superscript are significantly different ($P < 0.05$).

**Table 2b: Influence of Hydrocolloids (0.4 %) and Taro Starch (2 %) on the Sensory Characteristics of Bread**

| Sample | Visual Appearance | Taste | Aroma | Crumb Softness | Overall* Acceptability |
|---|---|---|---|---|---|
| TS | 4.00 ± 0.2[a] | 3.72 ± 0.3[a] | 4.11 ± 0.3[a] | 3.17 ± 0.1[a] | 3.68 ± 0.2[a] |
| TSA2 | 3.38 ± 0.2[b] | 3.66 ± 0.1[a] | 3.95 ± 0.2[b] | 2.92 ± 0.2[b] | 3.40 ± 0.2[b] |
| TSC2 | 4.04 ± 0.4[a] | 3.72 ± 0.2[a] | 4.14 ± 0.1[a] | 3.12 ± 0.3[a] | 3.73 ± 0.2[a] |
| TSG2 | 4.60 ± 0.1[c] | 3.70 ± 0.4[a] | 4.05 ± 0.2[a] | 3.75 ± 0.2[c] | 4.10 ± 0.1[c] |
| TSX2 | 4.32 ± 0.2[d] | 3.65 ± 0.2[a] | 4.12 ± 0.3[a] | 3.58 ± 0.3 [d] | 3.94 ± 0.3[c] |

Five point hedonic scale ratings: 5 = like extremely and 1 = dislike extremely.
*Overall acceptability was calculated by weighted arithmetic mean, given the following weight to each attribute: Visual appearance 35%, Taste 15%, Aroma 15% and Crumb softness 35%.
Values are means ± SD of triplicates.
Values in the same column with different superscript are significantly different ($P < 0.05$).

**Table 2c: Influence of Hydrocolloids (0.6 %) and Taro Starch (2 %) on the Sensory Characteristics of Bread**

| Sample | Visual Appearance | Taste | Aroma | Crumb Softness | Overall* Acceptability |
|---|---|---|---|---|---|
| TS | 4.00 ± 0.2[a] | 3.72 ± 0.3[a] | 4.11 ± 0.3[a] | 3.17 ± 0.3[a] | 3.68 ± 0.2[a] |
| TSA3 | 3.28 ± 0.4[b] | 3.55 ± 0.2[b] | 4.04 ± 0.3[b] | 2.77 ± 0.2[b] | 3.21 ± 0.3[b] |
| TSC3 | 3.90 ± 0.2[a] | 3.62 ± 0.2[b] | 4.12 ± 0.2[a] | 3.00 ± 0.3[c] | 3.58 ± 0.3[a] |
| TSG3 | 4.45 ± 0.1[c] | 3.51 ± 0.1[b] | 4.00 ± 0.1[b] | 3.30 ± 0.2[d] | 3.84 ± 0.2[c] |
| TSX3 | 4.20 ± 0.2[a] | 3.63 ± 0.2[a] | 4.05 ± 0.2[b] | 3.22 ± 0.2[a] | 3.69 ± 0.1[a] |

Five point hedonic scale ratings: 5 = like extremely and 1 = dislike extremely.
*Overall acceptability was calculated by weighted arithmetic mean, given the following weight to each attribute: Visual appearance 35%, Taste 15%, Aroma 15% and Crumb softness 35%.
Values are means ± SD of triplicates.
Values in the same column with different superscript are significantly different ($P < 0.05$).

was noted that, the improvement in specific volume of bread was evident at 0.2 % gum concentration with taro starch. Only slight improvement was observed at higher gum concentration, suggesting that 0.2 % guar and xanthan gum concentration is sufficient for obtaining high bread volume. The results obtained with guar and xanthan gums supplementations were in agreement with previous reports [25-28]. They also observed significant improvement in loaf volume when guar was added to wheat bread. It seems that both guar and xanthan gave stability and increased the gas retention ability to the dough during proofing; eventually better volume was obtained during baking [26, 29-30].

It was found that moisture content of the bread crumb was increased by the addition of hydrocolloids with taro starch and that increase was high enough at high hydrocolloid concentration (0.6%), in which TSG gave the highest value. Generally, the dough for bread was prepared at constant consistency and relatively higher amount of water was required in the presence of hydrocolloids to reach as required consistency as that of control [23, 31]. It has already been mentioned that xanthan gum has high hydrophilic ability, so its water absorption value is relatively high as compared to other tested hydrocolloids [11]. Therefore high crumb moisture was obtained by the incorporation of xanthan gum-taro starch blend. No significant change was observed by the addition of TSA.

The shape of the loaf slices was affected by the hydrocolloids in different ways. The addition of TSG and TSX successfully modified the slice shape, as they reduced the width/height ratio of bread. A greater effect was observed when TSG3 was added. Similar effect has also been reported for xanthan gum by Guarda *et al*. [23] and for guar gum by Marco & Rosell [32]. The addition of TSC slightly reduced the width/height ratio and thus played a role in improvement of the slice shape of the resulting bread. Conversely, TSA increased the width/height ratio, suggesting the poor performance regarding the shape of bread.

## Crumb Firmness

Both TSG and TSX showed a substantial reduction in crumb firmness particularly at low gum concentration i.e 0.2 % and giving softer crumb than the control. However, TSA increased the firmness of the bread crumb by providing the thickening effect to the crumb air cells walls [23]. However, Asghar and coworkers [33] have eported reduction in bread firmness by the addition of arabic gum.

The result obtained with TSG and TSX were somewhat similar with the previous report of Rosell *et al*. [11]. It seems that TSX and TSG provided a weakening effect to cell walls structure that in turns decreased the crumb resistance [26, 34]. In the beginning, hydrocolloids increase the firmness of bread by decreasing the swelling of the starch granules, and then they inhibit the amylose reassociation which lead to the weakening effect on the starch chains networking [34-35]. However, each effect will be dependent on the specific hydrocolloid. In relation to hydrocolloid concentration, it was observed that 0.2 % xanthan and guar gums are sufficient to reduce desired crumb firmness and no further improvement was obtained by increasing the hydrocolloid concentration.

### Sensory Evaluation

The sensory parameters assessment of the bread with or without hydrocolloids was carried out by 10 judges, who evaluated numbers of sensory attributes including visual appearance, taste, aroma and crumb softness. It was found that both TSG and TSX improved the appearance of bread. It was further observed that TSG2 received the highest score suggesting the best performance regarding the visual appearance of bread. However, bread with TSA were of minimum score being even worst by TSA3 suggesting the poor performance among all the tested hydrocolloids. When compared to taste scores, it was noted that all tested hydrocolloids did not alter the taste of bread even at 0.4 % gum concentration. However, TSG3 and TSA3 reduced the taste perception i.e. at high gum concentration 0.6 %. It was also found that only a slight improvement in aroma was observed with TSC (Taro starch- 0.2 % CMC) suggesting that hydrocolloids do not affect the aroma of bread. Furthermore, all hydrocolloids blends, with the exception of TSA, received higher scores regarding crumb softness as compared to the control. The data indicated that both TSG and TSX substantially improved the crumb softness. It was interesting to note that that maximum softness was obtained at 0.2% gum concentration and then it gradually reduced by increasing the gum concentration. Sensory analysis revealed that TSG and TSX improved sensory characteristics of bread as indicated by their higher scores for overall acceptability. The improvement in quality of the bread by the addition of guar gum is supported by numerous previous studies [28, 30, 36]. However, the positive effect of xanthan on bread sensory characteristics is unexpected as different studies reported no considerable effect or even negative effect [30, 36]. This could be a result of incorporation of taro starch which gave synergistic effect by developing strong association with xanthan gums chains and made the bread more acceptable. Similar positive effect of xanthan gum was reported by Shittu *et al*. [37] for cassava containing bread.

## CONCLUSION

These findings concluded that the resultant hydrocolloid-taro starch mixture, particularly with guar and xanthan gums, can be used as a novel ingredient to improve the functional and sensory characteristics of yeast leavened bread. It was also concluded that taro starch-hydrocolloids blends have remarkable potential and their application make them better suited as functional food additives in food industries.

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