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# Effect of Modified Water Chestnut *(Trapa bispinosa)* Starch on Physical and Sensory Properties of Sponge Cakes

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**Abstract.** Study of the effect of chemically and physically modified water chestnut (*Trapa bispinosa*) starch on volume index, symmetry index and uniformity index of sponge cake revealed that addition of acetylated starch (3%) increased the volume index of control sponge cake to a greater extent. In case of acid-thinned starch, increase in symmetry index was not very significant except that of concentration of 1%. At 4% - 5% concentration, pregelatinized starch and acid-thinned starch showed excellent uniformity index. Acetylated starch at 1% and 5% concentration significantly increased the grain structure.

**Keywords:** water chestnut starch, symmetry index of cakes, uniformity index of cakes, volume index of cakes, starch, cakes

## Introduction

Native and modified starch obtained from a number of plants sources, such as corn and other cereal grains and roots, are used in food, paper and textile industries. Modified starch can be obtained through chemical, physical or enzymatic process. (Singh *et al*., 2007; Jobling, 2004; Thomas and Atwell, 1999).

Uses of native (unmodified) starch have certain shortcomings which sometimes limit their wider application and industrial use. Addition of modified starch to bakery goods yields benefits that may not be achieved by the use of wheat flour alone. Primary benefits of adding modified starch are moisture retention and texture improvement. It also improves cell structure, increases volume, enhances shelf life and prevents particles from setting. Pregelatinized starch with swelling ability in cold water have been used in products such as thin muffin batters containing fruit particles (e.g. blueberries) that would otherwise settle to the bottom before the thickening effect of the wheat starch sets in during baking (Thomas and Atwell, 1999).

Modified starch, particularly lightly cross linked and substituted pregelatinized starch, help in binding the moisture present in the baked foods thus providing improved tenderness in the final product and contributing to the development of a fine, uniform cell structure, better paste clarity and stability, increased resistance to retrogradation and freeze-thaw-stability (BeMiller, 1997; Glover *et al*., 1986). They also extend shelf life and enhance the textural properties of cakes, cookies and other sweet goods.

Natural and modified starch are also the most economic fillers. In many products, they are used as neutral raw material to prevent aggregation of small particles and provide dispersion of viscous and non-viscous compounds by penetrating between the surfaces. Starch also prevent the products from cracking, crumbling and water exudation (Karaoglu *et al*., 2001). Several studies have been carried out showing the potential use of hydrocolloids in microwave baked cakes (Gomez *et al*., 2007; Seyhun *et al*., 2005).

The objective of the present study is to overcome the structural and textural problems encountered in cake making by addition of modified starch in the formulations.

## Materials and Methods

Dried water chestnut, what flour, sugar, fresh eggs and dried milk powder were purchased from local markets of Karachi, Pakistan.

Starch was extracted from dried water chestnut and modified physically and chemically. Six different types of starch were used in cake formulations i.e. native (nWCS), acid-thinned (atWCS), acetylated (aWCS) and pregelatinized (pgWCS), as well as double modified i.e. pregelatinization followed by acid-thinning (pgatWCS)and pregelatinization followed by acetylation.

**Isolation of starch.** The selected dehydrated water chestnuts were comminuted and 1 kg of sample was stirred for 30 min. with 2 litres of water, while maintaining pH at 9.0 by adding 0.2% sodium hydroxide solution. The slurry was filtered through 100 and 170 mesh sieves and consequently centrifuged at 3000 rpm using a Beckman Coulter Allegra™ X-22 centrifuge. The residue was washed with tap water to remove colour pigments. The starch was then air dried in oven at 45 ± 1 °C to 13% moisture content (Tulyathan *et al*., 2004).

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**Pregelatinization of starch.** Pregelatinization method as described by Waliszewski *et al*. (2003) was used. A sample of 300 g starch was suspended in 1 litre of distilled water and heated to 80 °C for 15 min with slow stirring. Pregelatinized starch was placed on stainless steel tray in the form of a thin film (1-2 mm) and dried in a convection oven at 40 °C for 48 h, ground in mortar to pass through a 100 mesh screen and stored at room temperature in air tight glass jar.

**Acetylation.** The method of Sathe and Salumkhe *et al*. (1981) was used for acetylation. 100 g of starch were dispersed in 500 ml of distilled water and stirred for 20 min. The pH of the slurry was adjusted to 8.0 using 1 M NaOH. Acetic anhydride (10.2 g) was added over a period of 1 h, while maintaining the pH range of 8.0-8.5 and thereafter the reaction was allowed to proceed for 5 min. pH of the slurry was adjusted to 4.5 using 0.5 M HCl. It was then filtered and washed four times with distilled water before drying at 30 ± 2 °C for 48 h.

**Acid-thinning.** The method of Lawal (2004), was employed with some modifications for acid-thinning. 100 g of native water chestnut starch was slurried in 500 ml of 0.05 M HCl. The mixture was stirred for 8 h, while maintaining the temperature at 50 °C. The acid-modified starch was filtered and the residue was washed four times with distilled water. It was air dried for 48 h at 30 ± 2 °C.

**Pregelatinization followed by acid thinning.** Pregelatinization was carried out by the method described by Waliszewski *et al*. (2003) followed by acid-thinning (Lawal, 2004).

**Pregelatinization followed by acetylation.** Pregelatinization (Waliszewski *et al*., 2003) was followed by acetylation (Sathe and Salunkhe, 1981).

**Preparation of baking powder.** Baking powder was prepared according to the American Association of Cereal Chemists Approved Methods 10-90 (AACC, 2000).

**Preparation of sponge cake.** Cakes were made according to the American Association of Cereal Chemists Approved Methods 10-90 (AACC, 2000). All the cakes, except control, were supplemented with 1%, 2%, 3%, 4%, 5% and 6% (flour weight basis) of each modified and unmodified starch.

**Physical measurements.** Uniformity, volume and symmetry indices were determined by the approved method of AACC (2000). Digital caliber was used to measure the cake height in mm; density of cakes was also determined. Each baked product was allowed to cool to room temperature (left for about 1 h after baking) prior to quality measurement.

**Sensory evaluation of sponge cakes.** The samples were labelled randomly with three digit numerical codes and the method of AACC (2000) was followed for the evaluation of cake quality on the basis of taste, aroma, colour, mouth feel, surface appearance and texture. During the taste panel session, the members were instructed to rinse their mouths with water and eat unsalted crackers before tasting each sample (Celik *et al*., 2006). The control cake was presented simultaneously with the rest of samples and was evaluated in random order by the panelists.

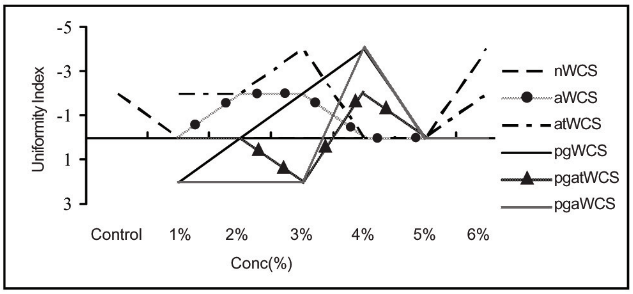
## Results and Discussion

**Effect of modified and unmodified starch on physical properties of cakes.** Physical parameters of sponge cakes i.e. volume index, symmetry index and uniformity index, after the addition of unmodified and modified water chestnut starch at varying concentration are shown in Fig. 1.1 - 1.5. Volume index is an indicator of the volume of the cake, whereas symmetry index indicates the difference in height between the central zone and the lateral zone, giving an idea of the gas retention in the final baking phase. Thus, high symmetry suggests that cakes mainly rise in their central part, while a negative symmetry indicates that cake volume falls down at the end of the baking process.

The differences in the symmetry, uniformity and volume index for all sponge cakes were less apparent; however, addition of acetylated water chestnut starch (3%) increased the volume index of control sponge cake to a greater extent. Addition of atWCS, pgWCS and pgaWCS at all concentrations decreased volume index of sponge cakes, whereas pgatWCS increased the index at 6% concentration.

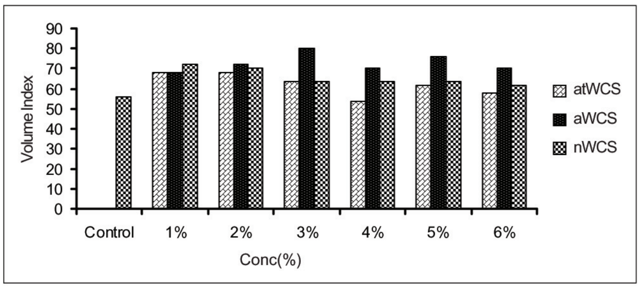
Better symmetry of sponge cakes was noticed after the addition of modified starch as compared to the control cake (Fig. 1.4-1.5). By the addition of aWCS, symmetry index increased at almost all concentrations, however, the maximum increase was observed at 3%-5%. The only decrease was notable at 2% concentration. In case of acid-thinned starch, increasing pattern of symmetry index was observed but was not very significant except at concentration of 1%. Double modified starch (pgatWCS) also markedly increased the symmetry index, while at 2% concentration no significant change was observed, where as double modified starch (pgaWCS) increased at only 5% concentration. Better symmetry index was observed at 4%-5% concentration by the addition of pgWCS.

The highest level of addition (6%) of the modified (acetylated) starch caused the greatest increase in uniformity index while with 2-3% addition, a decrease in uniformity index was observed. At 4%-5% addition, atWCS showed excellent uniformity index whereas with 1%-2% addition, the value was



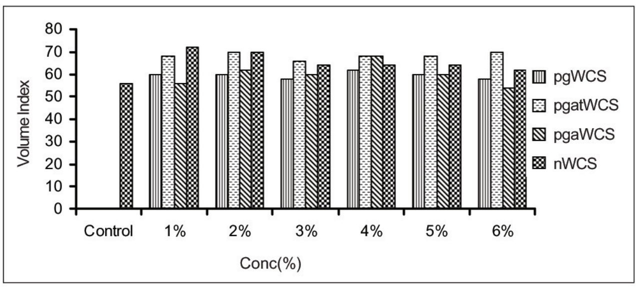

* control = without starch

**Fig. 1.1.** Effect on uniformity index of sponge cakes by the addition of nWCS, aWCS, atWCS, pgWCS, pgatWCS and pgaWCS at varying concentrations.




* control = without starch

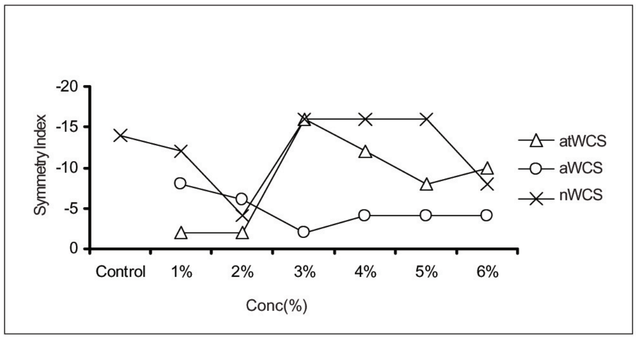
**Fig. 1.2.** Effect on volume index of sponge cakes by the addition of nWCS, aWCS, and atWCS at varying concentrations.




* control = without starch

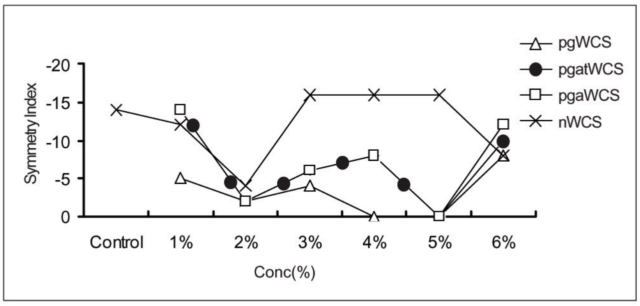
**Fig. 1.3.** Effect on volume index of sponge cakes by the addition of nWCS, pgWCS, pgatWCS and pgaWCS at varying concentrations.

almost zero. nWCS gave better results as compared to atWCS but with 6% addition, modified starch gave better results than that of native starch. At 3% concentration nWCS showed better uniformity index as compared to the same percentage of the double modified starch (pgatWCS). Uniformity index of sponge cake was significantly increased by the addition of




* control = without starch

**Fig. 1.4.** Effect on symmetry index of sponge cakes by the addition of nWCS, aWCS, and atWCS at varying concentrations.




* control = without starch

**Fig. 1.5.** Effect on symmetry index of sponge cakes by the addition of nWCS, pgWCS, pgatWCS and pgaWCS at varying concentrations.

**Key to Figs.** nWCS (native water chestnut starch); aWCS (acetylaed water chestnut starch), atWCS (acid thinned water chestnut starch), pgWCS (pregelatinized water chestnuts tarch), pgatWCS (pregelatinization followed by acid thinning, water chestnut starch), pgaWCS (pregelatinization followed by acetylation, water chestnut starch).

pgWCS as well as double modified starch (pgaWCS) at 6% concentration.

**Effect of modified and unmodified starch on sensory evaluation.** The effect of unmodified and modified water chestnut starch on the sensory attributes of sponge cakes (Table 1) was significant. By the addition of native starch at 1%, 2% and 6% concentration, there was enhancement of cells structure as compared to the sponge cake without the addition of starch. However, the bad grain structure was observed at all concentrations. An enhancement in the texture was observed at 1% concentration but there was no significant effect on crumb colour and flavour of the sponge cake by the addition of

**Table. 1.** Effect of varying concentrations of nWCS, aWCS, at WCS, pgWCS, pgatWCS and pgaWCS on sensory properties of sponge cake

| Starches | Concentrations | | | | | |
|---|---|---|---|---|---|---|
| | 1% | 2% | 3% | 4% | 5% | 6% |
| | **Cells** | | | | | |
| Control* = 22.4 | | | | | | |
| nWCS | 21 | 21 | 15.5 | 15 | 15 | 22 |
| aWCS | 20.4 | 23.6 | 19.2 | 17.6 | 20 | 14.8 |
| atWCS | 19.6 | 18 | 12.8 | 10.4 | 10 | 10 |
| pgWCS | 20 | 16 | 18 | 22 | 20 | 21 |
| pgatWCS | 19 | 21 | 16 | 6 | 20 | 22 |
| pgaWCS | 25.33 | 25.3 | 21.3 | 25.3 | 24.6 | 25.3 |
| | **Grains** | | | | | |
| Contol* =12 | | | | | | |
| nWCS | 12 | 12 | 10 | 10.5 | 11 | 11 |
| aWCS | 13.6 | 11.6 | 12.4 | 12.4 | 13.6 | 11.2 |
| atWCS | 10.8 | 10.8 | 10 | 8.4 | 8.8 | 10.4 |
| pgWCS | 11 | 11 | 10 | 8.4 | 8.8 | 10.4 |
| pgatWCS | 12 | 10 | 10 | 9 | 12 | 10 |
| pgaWCS | 10.6 | 8.6 | 11.3 | 13.3 | 8.6 | 8.6 |
| | **Texture** | | | | | |
| Control* = 22.8 | | | | | | |
| nWCS | 31.5 | 30 | 28.5 | 27.5 | 27.5 | 28.5 |
| aWCS | 30 | 30.4 | 30 | 31.6 | 29.6 | 29.6 |
| atWCS | 25.2 | 26.4 | 22.4 | 22.4 | 20.8 | 26 |
| pgWCS | 26 | 28 | 23 | 22.4 | 21 | 26 |
| pgatWCS | 30 | 30 | 27 | 26 | 27 | 28 |
| pgaWCS | 30 | 30 | 31.33 | 29.3 | 29.3 | 29.3 |
| | **Crumb colour** | | | | | |
| Control* = 6 | | | | | | |
| nWCS | 7 | 6 | 7 | 6 | 9 | 7 |
| aWCS | 7.2 | 6.8 | 7.2 | 6.8 | 7.2 | 6 |
| atWCS | 5.6 | 6.4 | 4.8 | 7.2 | 7.2 | 7.2 |
| pgWCS | 7 | 6.4 | 5 | 8 | 7.2 | 8.5 |
| pgatWCS | 8 | 7 | 8 | 7 | 8 | 7 |
| pgaWCS | 8 | 7.33 | 7.3 | 7.3 | 7.33 | 7.3 |
| | **Flavour** | | | | | |
| Control* = 10 | | | | | | |
| nWCS | 10 | 10 | 5 | 10 | 5 | 5 |
| aWCS | 10 | 10 | 10 | 10 | 8 | 8 |
| atWCS | 10 | 10 | 4 | 8 | 6 | 6 |
| pgWCS | 10 | 10 | 10 | 10 | 10 | 10 |
| pgatWCS | 10 | 10 | 10 | 10 | 10 | 10 |
| pgaWCS | 10 | 10 | 10 | 10 | 10 | 10 |

* Control = without starch

**Key:** nWCS (native water chestnut starch); aWCS (acetylaed water chestnut starch); atWCS (acid thinned water chestnut starch); pgWCS (pregelatinized water chestnuts tarch); pgatWCS (pregelatinization followed by acid thinning water chestnut starch); pgaWCS (pregelatinization followed by acetylation water chestnut starch)

native starch. Addition of aWCS at 1% and 5% concentration, significantly increased the grain structure comparative to the addition of native starch.

Acid-thinned starch showed overall decreasing effect on the sensory properties of sponge cake. Sensory panelist gave low score to the acid-thinned cake. Double modified starch (pgatWCS) showed significant decrease in cell structure whereas other sensory properties were quite similar to the other cakes. Double modified starch (pgaWCS) increased the overall sensory properties of sponge cakes.

Thus, it was noticed that addition of unmodified and modified starch at different concentrations to the sponge cake increased its sensory properties.

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