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Quality of Soft Drinks Products in Bangladesh: Analysis in the Framework of ARCH Model

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Abstract: The main purpose of this study is to examine the volatility of the quality of Soft Drinks products and its related stylized facts using Autoregressive Conditional Heteroscedastic (ARCH) models. The Soft Drinks products of analysis 57 (fifty seven) data were collected from Institute of Food Science and Technology (IFST), Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka over the year 2007 to 2012 in the method of single stage cluster sampling. Volatility as a measure of risk plays an important role in many qualitative decisions in such a situations. The physiochemical analysis data was used to study the volatility in the quality of Soft Drinks products over a 5 years period. The adequacy of selected model tested using Autoregressive Conditional Heteroscedastic -Lagrange Multiplier (ARCH-LM) test. The results of figure 1 to 8 indicate that the volatility in the soft drinks exhibits the low or stable of volatility except Vitamin C (mg/100g) which is highly volatile in this time period. The study concludes that ARCH model explains volatility of the quality of Soft Drinks products.

Key words: ARCH-LM Test • Single Stage Cluster Sampling • Institute of Food Science and Technology (IFST); Physiochemical Analysis

INTRODUCTION

Description of Soft Drinks: Soda Pop Soft drinks beverages are non-alcoholic, carbonated drinks containing flavorings, sweeteners and other ingredients. No matter what your taste, sparkling beverages come in many forms, including regular, low-calorie, no-calorie, caffeinated and caffeine-free drinks [1].

Consumers are always looking for new tastes and formats for soft drinks, innovation are the key to success. For this reason, the soft drinks sector is one of the most fast-moving and dynamic industries in the food and drink manufacturing. The main categories of soft drink products are carbonates, fruit juices, dilutables, still and juice drinks and bottled waters [2].

Autoregressive Conditional Heteroscedastic Model (ARCH) Model: ARCH (Autoregressive Conditional Heteroscedastic) Model is the first and the basic model in stochastic variance modeling and is proposed by Engle [3]. The key point of this model is that it already changes the assumption of the variation in the error terms from constant Var $(\varepsilon_t) = \sigma^2$ to be a random sequence which depended on the past residuals $(\{\varepsilon_1 \ldots \varepsilon_{t-1}\})$. That is to say, this model has changed the restriction from homoscedastic to be heteroscedasticity. This breakthrough is explained by Baillie [4]. And this is an accurate change to reflect the volatility data's features. Let ε_t as a random variable that has a mean and a variance conditionally on the information set I_{t-1}, The ARCH model of ε_t has the following properties. Come from Terasvirta [5].

First,

$$E(\varepsilon_t | I_{t-1}) = 0 \quad (1)$$

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Table 1: Name of soft drinks that are included in the analysis

Sl. No.	Name of soft drinks	Sl. No.	Name of soft drinks
1.	Horse fellness Mixed fruit Energy Drinks	15.	Pina Colada Cocktail Mix
2.	Sprite	16.	Margarita Cocktail Mix
3.	Coca Cola	17.	Carabao Energy Drink
4.	Schweppes Soda Water	18.	Beckers Non-Alcoholic Malt Beverage
5.	Schweppes Tonic Water	19.	Holsten Non-Alcoholic Malt Beverage
6.	Horses Non-Alcoholic Beverage	20.	Hollander Malt Beverage
7.	Holsten Non-Alcoholic Beverage	21.	Horses Beverages
8.	Horses Malt Beverage	22.	Classe Royale Malt Beverage
9.	Red Bull Energy Drink	23.	Festival Malt Drink
10.	Horses Non- Alcoholic Malt Beverage	24.	EFES Malt Beverage
11.	Seven-up	25.	Lemon Soft Drink
12.	Power Plus Energy Drink	26.	Pure Drink
13.	Bacchus Energy Drink	27.	Shark Energy Drink
14.	Bloody Mary Cocktail Mix		

And second, conditional variance

$$\sigma_t^2 = E(\varepsilon_t^2 / I_{t-1}) \tag{2}$$

is a positive valued parametric function of I_{t-1}. The sequence $\{\varepsilon_t\}$ may be observed directly, or it may be got from the following formula. In the latter case, I can get.

$$\varepsilon_t = y_t - \mu_t(y_t) \tag{3}$$

where y_t is observed value and $\mu_t(y_t) = E(y_t| I_{t-1})$ is the conditional mean of y_t given I_{t-1}, [3] application was of this type. In what follows, the ε_t could beexpressed as another way on parametric forms of σ_t^2.

So, here ε_t is assumed as follows:

$$\varepsilon_t = z_t\sigma_t \tag{4}$$

where $\{z_t\}$ is a sequence of independent, identically distributed (iid) random variables with zero mean and unit variance. This implied:

$$\varepsilon_t \sim D(0, \sigma_t^2), \tag{5}$$

So the ARCH model of order q is like this:

$$\sigma_t^2 = \alpha_0 + \alpha_1\varepsilon_{t-1}^2 + \ldots\ldots\ldots\ldots\ldots\ldots + \alpha_q\varepsilon_{t-q}^2 = \alpha_0 + \sum_{i=1}^{q}\alpha_i\varepsilon_{t-i}^2 \tag{6}$$

where $\alpha_0 > 0$ and $\alpha_i = 0$, $i > 0$. To assure $\{\sigma_t^2\}$ is asymptotically stationary random sequence, I can assume that $\alpha_1 + \ldots + \alpha_q < 1$. This is the ARCH model.

With the generation of ARCH model, it already can explain many problems in many fields, for instance, interest rates, exchange rates and trade option and stock index returns [6]. Already used these models to achieve a variety of applications in their survey. It's different between forecasting the conditional variance of these series and forecasting the conditional mean of them because the conditional variance cannot be observed. So how to measure the conditional variance should be considered from [7].

The overall objective of the study is to investigate the use of ARCH model for forecasting volatility of the quality of soft drinks by using the physiochemical analysis data.

MATERIALS AND METHODS

ARCH Models: Engle [3] introduced ARCH model. ARCH model suggests that the variance of residuals at time t depend on the square errors terms from the past. The ARCH model can be defined as follow. Let Y_t is the return of the stock, then the following model is called ARCH (p) model.

$$Y_t = a_0 + \sum_{i=1}^{p} a_i Y_{t-i} + \sum_{j=1}^{q} b_j \varepsilon_{t-j} + \varepsilon_t \tag{7}$$

$$\varepsilon_t = u_t\sqrt{h_t} \tag{8}$$

$$h_t = \alpha_0 + \sum_{i=1}^{s}\alpha_i\varepsilon_{t-i}^2 \tag{9}$$

where, p and q are the order of autoregressive (AR) and moving-average (MA) process to yield an autoregressive–moving-average (ARMA) process. It is assumed that the error terms have zero mean and no autocorrelation at any lag. To specify an ARCH process it is assumed that the equation (8) can be decomposed in to two parts, u_t which is homoskedastic, with mean zero and $\sigma_u^2 = 1$ and h_t is heteroskedastic with variance given by equation (9).

The generalization of ARCH model is called GARCH model. [8] Generalized ARCH model as GARCH model by allowing the past conditional variances in the conditional variance equation. The generalization was done in the similar way as AR model was generalized to ARIMA model.

The GARCH model can be defined as follow,

Let Y_t be the return of a particular stock and suppose Y_t follow an ARIMA process,

$$Y_t = a_0 + \sum_{i=1}^{p} a_i Y_{t-i} + \sum_{j=1}^{q} b_j \varepsilon_{t-j} + \varepsilon_t \tag{10}$$

$$\varepsilon_t = u_t \sqrt{h_t} \tag{11}$$

$$h_t = \alpha_0 + \sum_{i=1}^{s} \alpha_i \varepsilon_{t-i}^2 + \sum_{j=1}^{r} \beta_j h_{t-j} \tag{12}$$

where, p and q are the order of AR and MA process to yield an ARIMA model. It is assumed that the error terms have zero mean and no autocorrelation. In equation (12) s is the order of ARCH terms and r is the order of GARCH process. Also α_i of order s is the coefficients of ARCH terms and β_j of order r are the coefficients of GARCH terms. The above Model is denoted by GARCH (s, r) model. It is important to remember that the GARCH model consist of two parts. One is an ARIMA equation and other is GARCH equation. If r = 0, the GARCH model reduced to ARCH model [9].

Properties of Unconditional Error Terms: Recalling the fact that the unconditional mean value is equal to zero and the unconditional variance is not changing over time based on the law of iterated expectations.

E[Y] = E[E[Y/X]]

where Y is a random variable and X is relevant known data. Assuming stationarity of the process, we can state for ARCH (1).

$$\sigma^2 = Var(\varepsilon_t) = E[\varepsilon_t^2] = E[E[\varepsilon_t^2 | R_{t-1}]] = E[\alpha_0 + \alpha_1 \varepsilon_{t-1}^2] = \alpha_0 + \alpha_1 E[\varepsilon_{t-1}^2] = \frac{\alpha_0}{1-\alpha_1}$$

and also for GARCH(1, 1) the unconditional variance could be expressed similarly

$$\sigma^2 = Var(\varepsilon_t) = E[\varepsilon_t^2] = E[E[\varepsilon_t^2 | R_{t-1}]] = \frac{\alpha_0}{1-\alpha_1-\beta_1}$$

[10].

Residual Test/ ARCH LM Test: This is a Lagrange multiplier (LM) tests for autoregressive conditional hetroskedasticity (ARCH) in the residuals. The test statistic is computed by an auxiliary regression as follows.

$$P_t = \alpha_1 P_{t-1} + u_t \Rightarrow u_t = P_t - \alpha_1 P_{t-1}$$

To test the null hypothesis that there is no ARCH up to order q in the residuals, the following regression is run.

$$u_t^2 = \lambda_0 + \left(\sum_{s=1}^{q} \lambda_s u_{t-s}^2 \right) + v_t$$

where, u_t is the residual. This is a regression of the squared residuals on constant and lagged squared residuals up to order q. The null hypothesis is that, λ_s=0 in the absence of ARCH components.

In a sample of T residuals under the null hypothesis of no ARCH errors, the LM test statistic equals number of observations*R-square (TR^2). The test statistic TR^2 follows Chi (χ^2)-distribution with q (lag length) degrees of freedom. If TR^2 calculated is greater than the chi-square table value (TR^2 critical), reject the null hypothesis in favour of the alternate hypothesis. Hence there is ARCH effect in the GARCH model [11].

Unit Root Test: In the case of time series analysis, unit root tests are important. Unit root tests help to identify the stationarity and non-stationarity of time series data used for the study. A stationary time series has three basic properties. First, it has a finite mean. This means that a stationary series fluctuates around a constant long run mean. Second, a stationary time series has a finite variance. This means that variance is time invariant and third, a stationary time series has a finite (Auto) covariance. This reflects that theoretical autocorrelation decay fast as lag length increases. Regressions run on non-stationary time Series produce a spurious relationship. Hence, to avoid a spurious relationship, there is a need to perform a unit root test on variables [12]. This thesis uses Dickey–Fuller (DF) test for performing unit root tests.

Dickey – Fuller (DF) has been widely used to check the stationarity and presence of unit root of a process. The Dickey – Fuller test is valid only for AR (1). We use the DF test when the residual are not autocorrelated. Dickey – Fuller considered the estimation of the parameter α from the models.

1. $y_t = \alpha y_{t-1} + e_t$ (Pure random walk)
2. $y_t = \mu + \alpha y_{t-1} + e_t$ (Drift + random walk)
3. $y_t = \mu + bt + \alpha y_{t-1} + e_t$ (Drift + linear trend)

It assumes that $y_0=0$ and $e_t \sim$i.i.d $(0, \sigma^2)$

The null and alternative hypotheses are:

H_0: $\alpha=1$ ($\alpha(z)=0$ has a unit root)
H_1: $|\alpha| <1$ ($\alpha(z)=0$ has root outside unit circle) [13, 14]. Using non-stationary time series data in financial models produces unreliable and spurious results and leads to poor understanding and forecasting [15].

Data: The Soft Drinks products analyzed 57 observations were collected from different analytical laboratory of Institute of Food Science and Technology (IFST), Bangladesh Council of Scientific and Industrial Research (BCSIR) over the year from 2007 to 2012 by Single Stage Cluster Sampling method [16]. Data were analyzed using the method of autoregressive conditional heteroskedasticity (ARCH) model.

RESULTS AND DISCUSSION

ARCH-LM Test: To detect the presence of ARCH effect in the soft drinks we use the ARCH-LM (Lagrange multiplier) test.

In our analysis the different value for different variables of above parameters of the ARCH-LM test; the lags included in the test are only 1. The corresponding P-Value is <0.05, which is very low for Total Soluble Solid (%), Vitamin C (mg/100ml) and Gas Pressure (lb/in^2). So we have to reject the null hypothesis of no ARCH error and conclude that there is an ARCH error in the analysis series. This confirms that the order of the volatility for soft drinks products. Other parameters are insignificant that means no ARCH effects of the models. The results are given in the Table 2.

Table 2 shows that the values of DF test for all variables p-value <0.05 at 5%, level of significance except Vitamin C which implies that the variables series is stationary. An outcome of DF test confirms that the physiochemical analysis variables series is stationary.

Spike Behaviour of ARCH(1) and GARCH(1, 1) Model: The presence of extreme spikesin our analysis of soft drink products that is a bad characteristic of food products.

Figure 1 shows the conditional and unconditional standard deviation of pH content over the period April 2008 to March 2010. Conditional standard deviations are over 0.60 during the sample period. The results indicate that the standard deviation almost stable among 2008 to 2010 and in spike behavior in December 2008 and March 2010. However, volatility in deviations is very low in this time period.

Figure 2 shows the conditional and unconditional standard deviation of Total Soluble Solid (%) content over the period April 2008 to March 2010. Conditional standard deviations are over 4.80 during the sample period. The results indicate that the deviations relatively stable all over the period. However, volatility in deviation is low in this time period.

Figure 3 shows the conditional and unconditional standard deviation of Reducing Sugar (%) content over the period March 2008 to January 2010. Conditional standard deviations are over 3.0 during the sample period. In the Figure 3 shown that the deviation relatively stable all over the period and slight spike behavior in December 2009. However, volatility in deviation is low in this time period.

Figure 4 shows the conditional and unconditional standard deviation of Total Sugar (%) content over the period April 2008 to March 2010. Conditional deviations are over 3.00 during the sample period. The results indicate that the deviation relatively stable all over the period and slight spike behavior in December 2009. However, volatility in deviations is low in this time period.

Figure 5 shows conditional and unconditional standard deviation of Acidity (%) content over the period April 2008 to March 2010. Conditional deviations are over 0.08 during the sample period. As can be seen in Fig. 5.25, the deviation has relatively stable during sample period and spike behavior in April 2009. However, volatility in deviation is low in this time period.

Figure 6 shows the conditional and unconditional standard deviation of Standard Plate Count (cfu/ml) content over the period April 2008 to March 2010. Conditional deviations are over 40.26 during the sample period. The results indicate that the deviation relatively stable all over the period and spike behavior in November 2009.

Figure 7 shows the conditional and unconditional standard deviation of Vitamin C (mg/100g) content over the period April 2008 to March 2010. Conditional deviations are over 0.70 during the sample period. The results indicate that the deviations are highly spike behavior at first and last of the period 2008 and 2010 and relatively stable during the period 2009. The deviation is highly volatile during the period 2008–2010.

Table 2: ARCH-LM and DF test analysis results of chemical parameters of Soft drinks

	LM test for autoregressive conditional heteroskedasticity (ARCH)		Dickey-Fuller test for unit root	
Variable	Chi-square Statistic	P-value	Test Statistic, Z(t)	P-value
pH	1.259	0.2619	-6.240	0.0000
Total Soluble Solid (%)	4.915	0.0266	-5.296	0.0000
Reducing Sugar (%)	0.085	0.7701	-5.351	0.0000
Total Sugar (%)	2.968	0.0849	-5.033	0.0000
Acidity (%)	0.050	0.8228	-7.254	0.0000
Standard Plate Count (cfu/ml)	0.042	0.8379	-3.927	0.0018
Mold Count (cfu/ml)	0.006	0.9389	-29.235	0.0000
Alcohol (%)	0.072	0.7878	-3.922	0.0019
Vitamin C (mg/100ml)	5.895	0.0152	-2.398	0.1423
Gas Pressure (lb/in^2)	9.218	0.0024	-3.199	0.0201

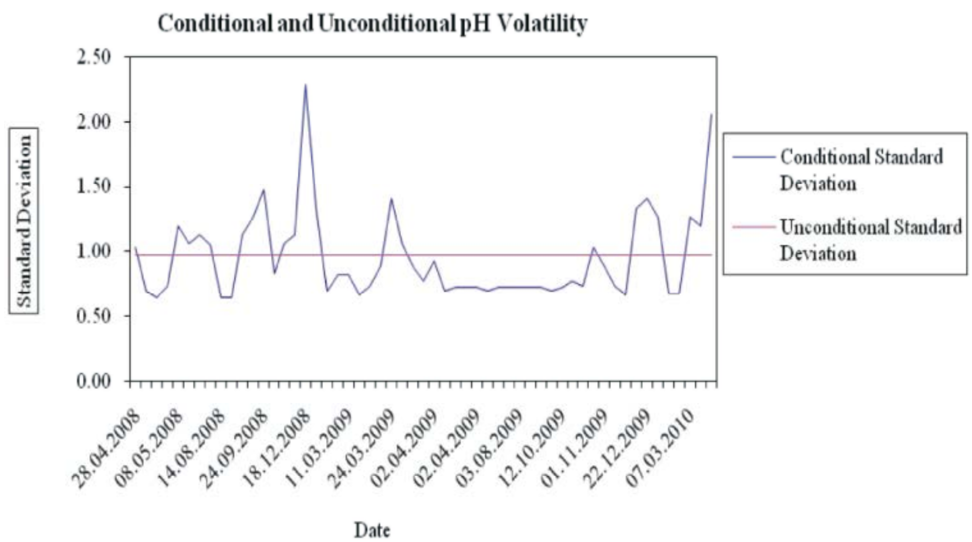

Fig. 1: pH content of Soft Drinks products for the Period April 2008 to March 2010

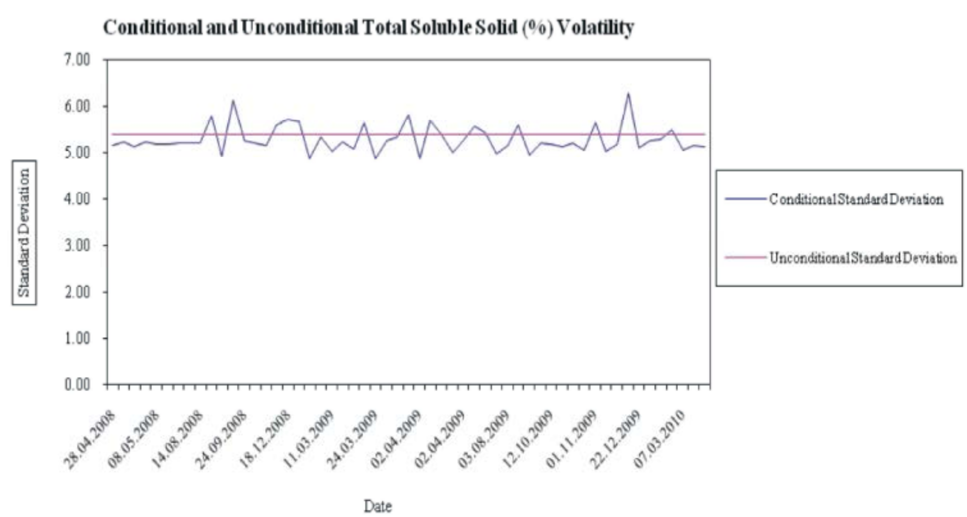

Fig. 2: Total Soluble Solid (%) content of Soft Drinks products for the Period April 2008 to March 2010.

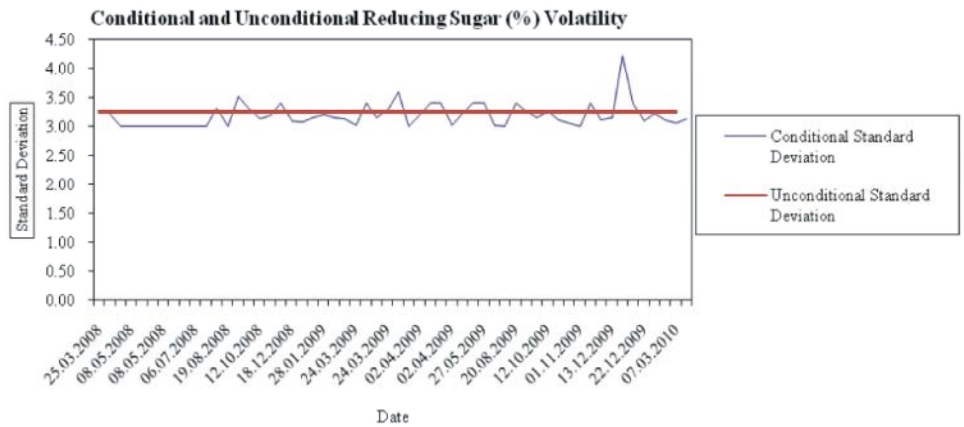

Fig. 3: Reducing Sugar (%) content of Soft Drinks products for the Period March 2008 to January 2010

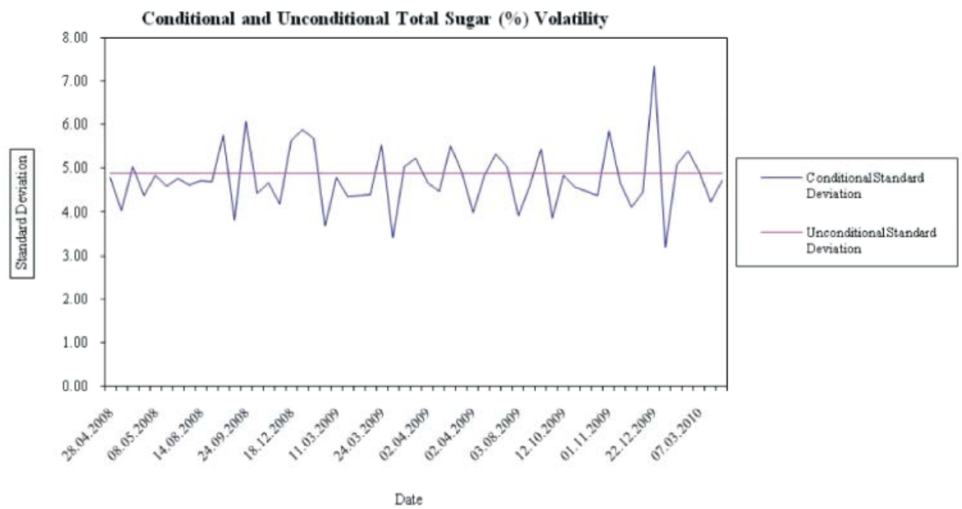

Fig. 4: Total Sugar (%) content of Soft Drinks products for the Period April 2008 to March 2010

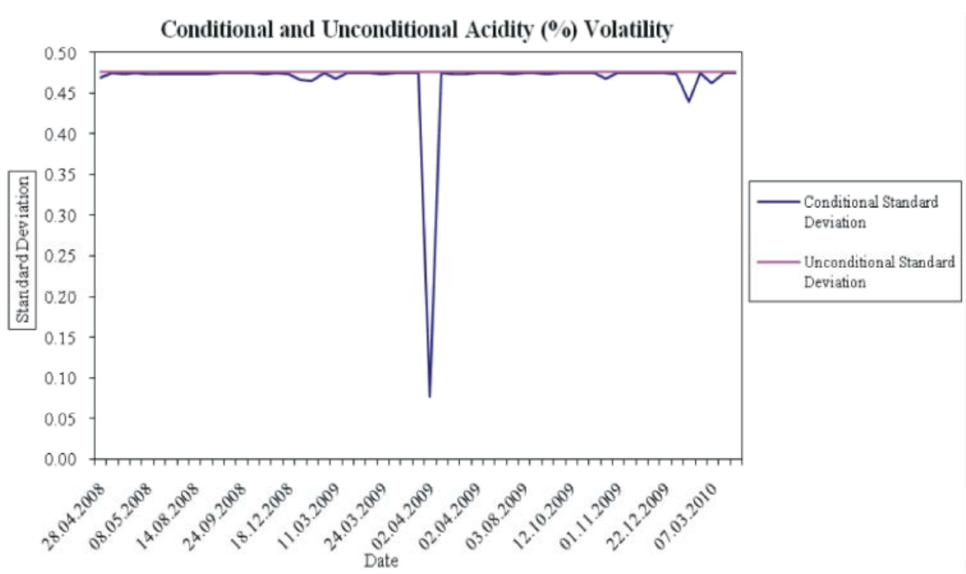

Fig. 5: Acidity (%) content of Soft Drinks products for the Period April 2008 to March 2010

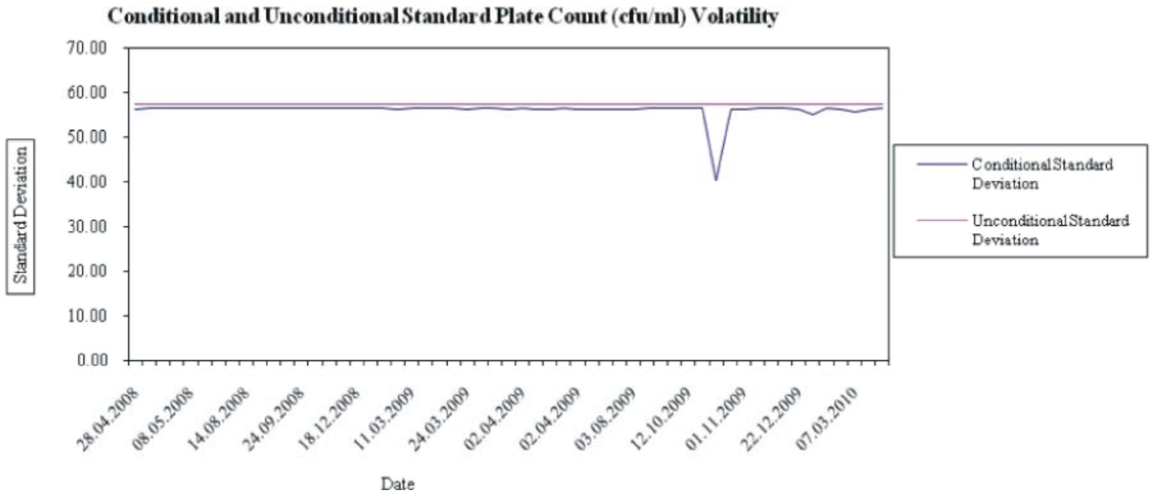

Fig. 6: Standard Plate Count (cfu/ml) content of Soft Drinks products for the Period April 2008 to March 2010

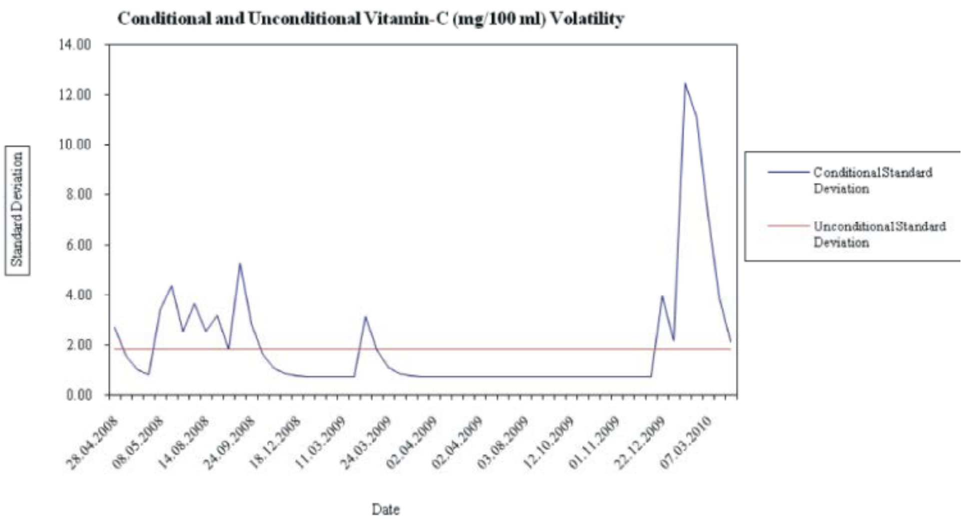

Fig. 7: Vitamin C (mg/100g) content of soft drinks products for the Period April 2008 to March 2010

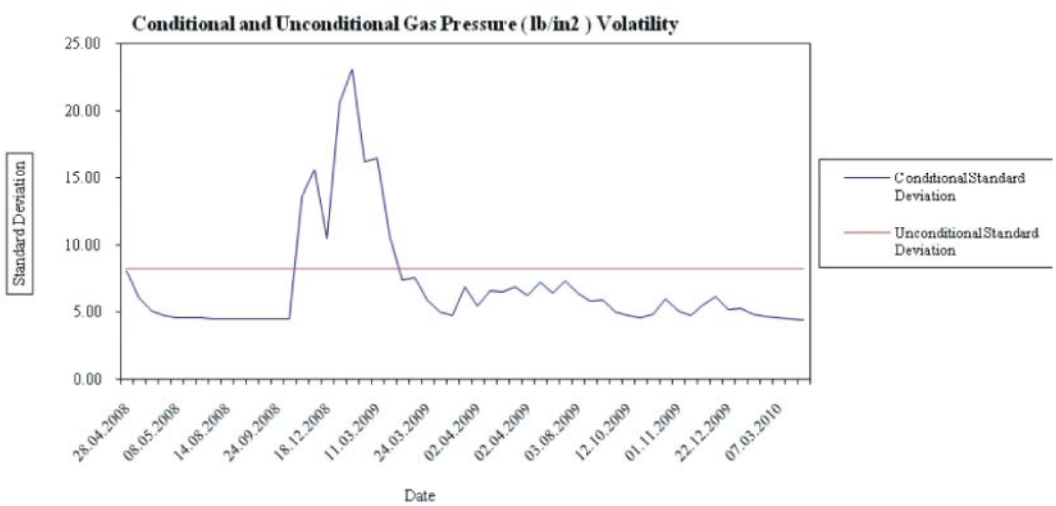

Fig. 8: Gas Pressure (lb/in^2) content of biscuit products for the Period April 2008 to March 20010

Figure 8 shows the conditional and unconditional standard deviation of Gas Pressure (lb/in^2) content over the period April 2008 to March 20010. Conditional deviations are over 4.50 during the sample period. The results indicate that the deviation relatively stable all over the period and spike behavior in December 2008 to March 2009. The results of Figure 1 to 8 indicate that the volatility in the soft drinks exhibits the low or stable of volatility except Vitamin C (mg/100g) which is highly volatile in this time period.

CONCLUTION

This study attempted to study the volatility in the quality of food products. The analyzed data were collected for the use of statistical technique over the period of 2007 to 2012. Empirical results showed that ARCH model can adequately describe the quality of food products. We use ARCH-LM test to test whether there is any further ARCH error in both series. The test results of some parameters in Soft Drinks products show that there is there is an ARCH error in the analysis series. The results suggest that the volatility in the quality of Soft Drinks products exhibits the persistence of volatility behavior. Our results revealed that the ARCH model satisfactorily explains volatility and is the most appropriate model for explaining volatility in the series under analysis. Government mechanism should continuously monitor the food products quality in Bangladesh on a regular basis for necessary analysis of the contents of Soft Drinks products. For this purpose regular sample analysis data should be collected and necessary statistical analysis should be done. Relevant academic and research institutions may investigate and generate information or data. This relevant organization should maintain a data bank of food products produced in our country for further statistical analysis.

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