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Research Article

Forecasting Volatility of Processed Milk Products in the frameworks of ARCH Model

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Abstract

Present work has explored the impact of type of food products on testing for ARCH effects and on the estimation of ARCH models for food products analysis data. Our sample comprises physiochemical and microbial analysis data for food products. The results of the food products forecasts reveal that processed milk products were forecasted to volatility of Tritratable Acidity (as lactic acid) (%) and Total Ash (on dry basis) (%) content which is highly volatile in this time period. The usual unit root tests results of the Dickey-Fuller test (DF) presented in study reject the null hypothesis of most of milk qualitative variable indicating that the series were stationary except Protein (%) and Total Ash (%). Hence, processed milk products qualitative analysis data are appropriate for this technique ARCH models of milk products analysis as expected.

Keywords: Physiochemical and Microbial analysis; ARCH effects; Forecasted to Volatility; Dickey–Fuller test.

Introduction

Average milk consumption in Bangladesh is the lowest compared to neighbouring countries. Its cost is the highest in the region due to low yield and high production cost, making it almost impossible for the majority people to have the nutritious food item. In Bangladesh, per capita daily calorie intake through milk is only 24 kilocalories, while in Sri Lanka it is 57, 82 in Nepal, 104 in India and 265 in Pakistan, according to statistical yearbook of Food and Agriculture Organisation (FAO). Nutritionists say milk is an ideal food that easily provides large amounts of calcium and protein to the body but inadequate intake of milk is causing calcium deficiency and bone-related diseases like rickets. They said nutrients of milk can be had from other food items but people are usually not conscious enough to get the nutrients from other sources. In the wake of the recent controversy over toxic melamine in milk, health and dairy experts said the best way to meet the milk demand is to expand dairy production at farm and household levels. According to FAO, average annual milk production in Bangladesh is 2,264,000 tonnes and only 13 kg of milk is available for every person annually. Low production results in the import of bulk amount of powdered milk. Bangladesh spent about Tk 1,500 crore to import 42,583.46 tonnes of powdered milk during the last fiscal year, said Tureen Afroze of United Nations Industrial Development Organisation (UNIDO). "On an average, a Bangladeshi cow produces around 200kg of milk a year, which is 30 percent lower than an Indian cow's production figures. This low milk yield is mainly caused by poor livestock feed and low milk production of the common breeds of cattle in Bangladesh," says a study of International Farm Choose Network (IFCN) on milk production in Bangladesh. According to dairy industry insiders, each kilogram of milk on an average sells between Tk 40 and Tk 45 but in India it is around Tk 22. A litre of pasteurized milk is sold at around Tk 47 in Bangladesh. Milk prices at farms of Bangladesh are about 40 to 50 percent higher than those of Indian and New Zealand farms, the IFCN study said. "First of all, we have low productivity of milk and then the prices are too high. Therefore, milk consumption by majority people of the country is almost impossible," said Prof M Nazmul Hasan of Institute of Food and Nutrition Science at Dhaka University. Citing a survey at Chokoria in Cox's Bazar, he said the survey found that nine percent of the children in that area suffered from rickets. "Calcium

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deficiency is being seen a lot in recent times. More and more people are suffering from bone-related diseases," Nazmul told The Daily Star. He suggested that the government should take strong steps to encourage dairy production at farm and household levels to meet the local demand because milk is an ideal food. Mohammad Ali, general manager of Brac Dairy and Food Project, told The Daily Star that shortage of fodder and low productivity of cattle are the two major factors that hold the dairy sector back. The dairy farms are mainly located in northern Bangladesh, he said, adding that the government could provide incentives like loan arrangements for farmers to rear cows at household level. Besides, cooperatives could be formed at village level to develop milk marketing system and ensure that the dairy farmers get due price of milk, he said, adding, "Dairy farms could reduce our unemployment problem." The government should come forward and help set up infrastructure for milk preservation, Mohammad Ali added [1, 2].

The analysis of chemical analysis data has received considerable attention in the literature over the last 20 years. Several models have been suggested for capturing special features of this data and most of these models have the property that the conditional variance (or the conditional scaling) depends on the past. One of the best known and most often used is the autoregressive conditionally heteroscedastic (ARCH) process introduced by[3]. The theoretical results on ARCH and related properties have played a special role in empirical work in the analysis of data on rates, prices and in inflation rate data to mention but a few [4]. This study is to examine the use of ARCH model for forecasting volatility of the Physicochemical analysis of soft drinks data collected from Institute of Food Science and Technology, Bangladesh Council of Scientific and Industrial Research, Dhaka over the year 2007 to 2012 by the method of single stage cluster sampling.

This first model is Autoregressive Conditional Heteroskedasticity (ARCH) which was early introduced in the [3], it aimed to capture the conditional variance that is why it became the most popular way of describing the unique feature. Later on, for making this model better [5] and [6] put forward, independently of each other, a generalization of this model, called Generalized ARCH (GARCH). And this model have been certificated not only to catch volatility clustering but also to contain fat tails from the volatility data. These are common features about the financial data. Even though the GARCH model is already the extension of the ARCH model, it still has some drawbacks. The main point is that the GARCH model is symmetric, so it has a poor performance in reflecting the asymmetry. Because a fact on an interesting feature of financial volatility data is that bad news seems to have a more significant effect on the fluctuation compared to good ones. In other words, positive and negative information generate different degrees of influence to the changes of financial data. So this asymmetric phenomenon is leverage effect. Considering the stock data, it always exist a strong negative correlation between the current return and the future conditional variance. That is why some advanced GARCH model will be introduced later. Such as exponential-GARCH model, [7] and GJR-GARCH model, [8], are proposed. Except these models, there still have many other extension GARCH models, such as TGARCH model-threshold ARCH-attributed to [9] and [8], FIGARCH model-introduced by [10] IGARCH model-proposed by [11] and so on [12].

Materials and methods

Data

The food sample analysed observations from different food products (Table 1) as Milk 32 data collected by Single Stage Cluster Sampling method from Institute of Food Science and Technology (IFST), BCSIR, Dhaka over the year from 2007 to 2012 [13]. Data collection methods were non-participant observation of organization included in the study. Archival research included hard-copy issues of reports of analytical documents.

Auto-regressive Conditional Heteoskedastic Model (ARCH) model

ARCH (Auto-regressive Conditional Heteoskedastic Model) is the first and the basic model in stochastic variance modeling and is proposed by [3]. The key point of this model is that it already changes the assumption of the variation in the error terms from constant Var (ε_t) = σ^2 to be a random sequence which depended on the past residuals ($\{\varepsilon_1 \dots \varepsilon_{t-1}\}$). That is to say, this model has changed the restriction from homoscedastic to be heteroscedasticity. This breakthrough is explained by [14]. 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}.

Table 1. Milk products included in analysis

Sl. No.	List of milk products
1.	Sagar Skimmed Milk
2.	Rajat Skimmed Milk
3.	Madhusudon Skimmed Milk
4.	Amul Spray Infant Milk
5.	Skim Milk Powder
6.	Dried Skimmed Milk (DSM)
7.	Milk Powder
8.	UHT milk
9.	Cow head Full Cream Milk
10.	Milk Chocolate
11.	UHT Milk Low Fat
12.	Aarong Pasteurized Milk
13.	Therapeutic Milk
14.	Fresh Sweetened Condensed filled Milk

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 a constant and lagged squared residuals up to order q. The null hypothesis is that, $\lambda_s=0$ 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 [15].

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 [16].

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 usethe DF test when the residual are not autocorrelated. Dickey – Fuller considered theestimation 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) [17, 18]. Using non-stationary time series data in financial models produces unreliable and spurious results and leads to poor understanding and forecasting [19].

Results and discussions

To detect the presence of ARCH effect in the mean equation of milk, 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 Protein (%), Total Ash (on dry basis) (%) and Tritratable Acidity (as lactic acid) (%). So to reject the null hypothesis of no ARCH error and conclude that there is an ARCH error in the data series. This confirms that the order of the ARCH error variables for analysis of milk food products. Whereas other parameters are insignificant that means no ARCH effects of the models. The estimated 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 for all variable except Protein (%)

and Total Ash (%) which implies that the variables series is stationary. An outcome of DF test confirms that the physiochemical analysis variables series is stationary.

Table 2. ARCH-LM and DF test analysis results of chemical analysis of Milk

Variable	LM test for autoregressive conditional heteroskedasticity (ARCH)		Dickey-Fuller test for unit root	
	Chi-square Statistic	p-value	Test Statistic, Z(t)	p-value
Moisture (%)	0.042	0.838	-3.439	0.0097
Protein (%)	10.623	0.001	-2.368	0.1509
Total Ash (on dry basis) (%)	12.467	0.000	-2.422	0.1355
Tritratable Acidity (as lactic acid) (%)	13.100	0.000	-2.905	0.0448
Solubility (%)	0.069	0.793	-3.174	0.0215
Total Milk Solid (%)	1.219	0.270	-3.322	0.0139
Standard Plate Count (cfu/g)	0.029	0.864	-4.889	0.0000

Spike Behaviour of ARCH(1) and GARCH (1, 1) model estimations

The presence of extreme spikesin our analysis of milk products that is a bad characteristic of food products. Fig. 1 shows the conditional and unconditional standard deviation of Moisture (%) content over the period November 2007 to February 2010. Conditional standard deviations are over 0.50 during the sample period. The results indicate that the standard deviation almost stable among 2007 to 2010 and in spike behaviour in January 2009 and February 2010. However, volatility in deviations is very low in this time period.

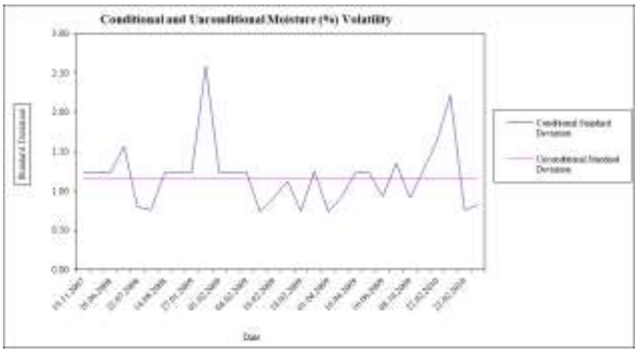

Fig. 1. Moisture (%) content of milk products for the Period November 2007 to February 2010

Fig. 2 shows the conditional and unconditional standard deviation of Protein (%) content over the period October 2007 to February 2010. Conditional standard deviations are over 8.00 during the sample period. The results indicate that the deviations increased significantly at 2008 and 2009 and decreased between February 2009 to 2010 and also in spike behaviour at October 2009. However, volatility in deviation is low in this time period.

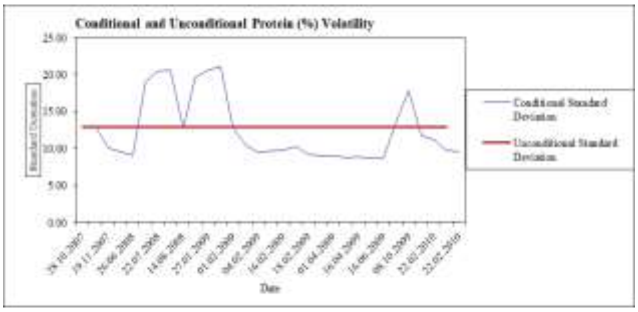

Fig. 2. Protein (%) content of Milk products for the Period October 2007 to February 2010

Fig. 3 shows the conditional and unconditional standard deviation of Total Ash (on dry basis) (%) content over the period November 2007 to February 2010. Conditional standard deviations are over 0.5 during the sample period. As can be seen in Fig. 3, the deviation has an increasing trend June 2008 to February 2009 and relatively stable then also ups and down in the period 2009 and 2010. However, volatility in deviation is high in this time period.

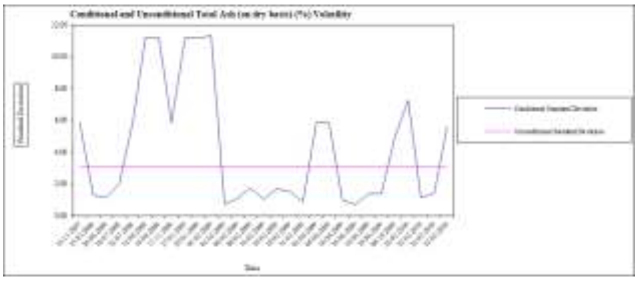

Fig. 3. Total Ash (on dry basis) (%) content of milk products for the Period November 2007 to February 2010

Fig. 4 shows the conditional and unconditional standard deviation of Solubility (%) content over the period November 2007 to February 2010. Conditional deviations are over 0.20 during the sample period. The results indicate that the deviations decreasing trend between 2007-2010 and also spike behaviour at February 2010. However, volatility in deviations is low in this time period.

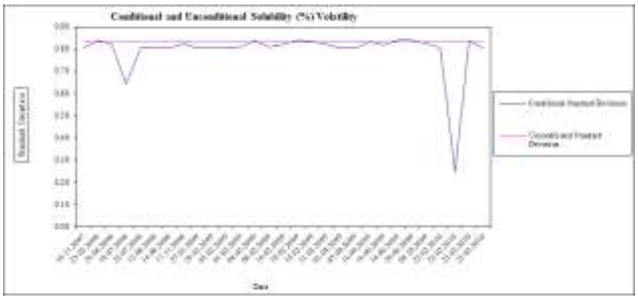

Fig. 4. Solubility (%) content of milk products for the Period November 2007 to February 2010

Fig. 5 shows conditional and unconditional standard deviation of Total Milk Solid (%) content over the period November 2007 to February 2010. Conditional deviations are over 1.5 during the sample period. As can be seen in Fig. 5, the deviation has relatively stable during sample period. However, volatility in deviation is low in this time period. The deviation is spike behaviour during the period 2007–2010.

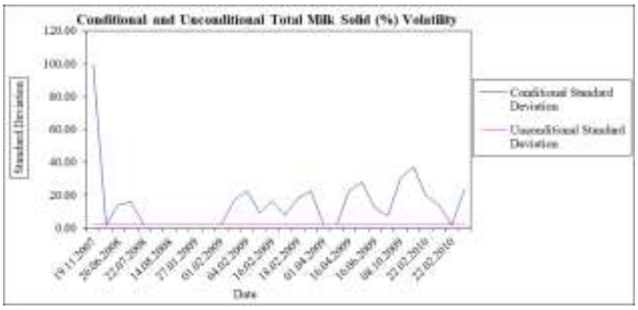

Fig. 5. Total Milk Solid (%) content of milk products for the Period November 2007 to February 2010

Fig. 6 shows the conditional and unconditional standard deviation of Tritratable Acidity (as lactic acid) (%) content over the period November 2007 to February 2010. Conditional deviations are over 0.35 during the sample period. The results indicate that the deviations are highly spike behaviour at first of the period 2008 and 2009. As can be seen in Fig. 6, the deviation has a decreasing trend between 2009-2010. The deviation is highly volatile during the period 2007–2010.

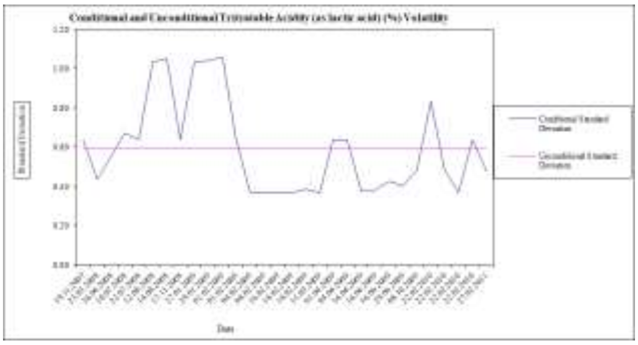

Fig. 6. Tritratable Acidity (as lactic acid) (%) content of milk products for the Period November 2007 to February 2010

Fig. 7 shows the conditional and unconditional standard deviation of Vitamin A (mcg/100g) content over the period November 2007 to February 2010. Conditional deviations are over 1200.00 during the sample period. The results indicate that the deviations are low spike behaviour at the period 2007 and 2009 and relatively high spike behaviour during the period March 2009 to October 2009. The deviation is low volatile during the period 2007–2010. The results of Fig. 1 to 7 indicate that the volatility in the milk exhibits the low of volatility except Tritratable Acidity (as lactic acid) (%) and Total Ash (on dry basis) (%) content which is highly volatile in this time period.

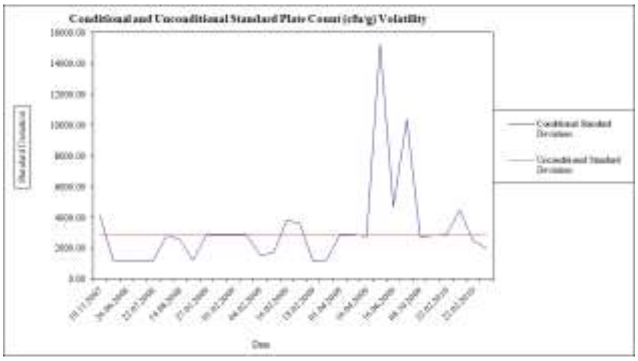

Fig. 7. Standard Plate Count (cfu/g) content of milk products for the Period November 2007 to February 2010

Conclusions

The present work was attempted to study the volatility in the quality of food products. The data used for analysis were observations for the period of 2007 to 2011. 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 food products show that there is there is an ARCH error in the analysis series. The results suggest that the volatility in the quality of food 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 food products. For this purpose regular sample analysis data should be collected and necessary statistical analysis should be done. Partnerships with relevant academic and research institutions to investigate and to generate information and data. This relevant organization should maintain a data bank of food products produced in our country for further statistical analysis.

Conflicts of interest

The authors declare no conflict of interest.

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