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ORIGINAL RESEARCH PAPER

EFFECTS OF THE ADDITION OF CANTHARELLUS CIBARIUS MUSHROOMS ON THE RHEOLOGICAL PROPERTIES OF BUTTERMILK

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Abstract: The purpose of the work is to obtain buttermilk with the addition of mushrooms and to evaluate some quality characteristics of the final product. Edible mushrooms such as *Cantharellus cibarius* have a multitude of health benefits. They contain a series of nutrients, ensure efficient digestion, they are very good for increasing immunity.

In the proposed research, the evolution of a buttermilk product was followed by the enrichment with mushrooms in different amounts of 10, 15 and 20 grams compared to the normal product. As a section of mushrooms, the attention was focused on the species *Cantharellus cibarius* often found in Romania. The assortments developed in different concentrations were compared from a physico-chemical point of view in order to note all the aspects that the mushroom species brings to buttermilk product.

In order to obtain the products, we started from the technology of obtaining buttermilk products with usual additions, and after the seeding process, before the product was packaged, the mushrooms were added in powder form, in the established concentrations.

From the analysis of the obtained results, it appears that the samples showed a decrease in acidity during the analyzed period, due to the appearance of the syneresis phenomenon, the product becoming more fluid. Viscosity analysis shows that the sample with the addition of 20 grams of mushrooms had the highest weight compared to the control sample with the lowest value.

Keywords: *buttermilk, Cantharellus cibarius, health benefits, physico-chemical determinations*

INTRODUCTION

Buttermilk is an acidic dairy product that is obtained through thermal treatments at high temperatures followed by fermentation by inoculation with the help of a starter culture formed by lactic streptococci that has the role of acidifier and aromatizer [1].
Fermented dairy products are an important part of the traditional diet, although their production and consumption are more common in some countries than others.
Notoriously, they include a very large variety of products obtained from milk by means of different combinations of fermentation and other biochemical activities with different technological interventions [2].
There are many reasons to choose the milk fermentation process, the main function being to increase the shelf life. Other advantages are represented on the one hand by improving the taste and digestibility of the product and on the other hand by the possibility of manufacturing a diversified range of products from plain yogurts or with various additions to cheeses [3].
Buttermilk is one of the most important by-products of the dairy industry. Recently, buttermilk has gained increasing attention due to its unique structure, characteristics, and promising applications. It is classified as a functional food because it contains water-soluble components, polar lipids and milk fat globule membranes [4]. When milk fat globules are broken during churning of cream, the membrane covering the lipid core is excluded from the lipid matrix and recovered in buttermilk along with most of the proteins, lactose and minerals contained in the aqueous phase of cream. The milk fat globule is rich in various proteins and phospholipids which have some potential for both functional and nutraceutical applications [5 – 9].
The milk fat globule membrane found in raw milk is rich in bioactive proteins. Protein is used by the body to make new cells and repair cells, in addition to helping with muscle growth and development [10].
The mushroom species used in the experiments is found in Romania and is widely consumed and known by consumers.
The mushroom species was chosen due to the variety of benefits it offers and the high protein content compared to other possible additions, for example vegetables.
Mushrooms, due to their unique flavor and taste, are an attractive delicacy and were used by early civilizations. The knowledge of numerous health benefits that some of these edible mushrooms afford also dates back several centuries. In fact, several thousand years ago in eastern cultures, many edible and non-edible mushrooms were recognized for their potential health benefits [11].
Vegetable protein obtained from mushrooms ranks second worldwide after soybean. Edible mushrooms are generally considered foods of high nutritional value. The chemical composition of fungi differs from one species to another depending on the stage of development, the nutrient substrate they grow, the morphological aspect taken into account, the growth period, the microclimate conditions, etc. Laboratory analyzes have shown that 100 - 200 g of dried mushrooms consumed daily by humans can replace meat consumption [12].
Cantharellus cibarius is a species of edible fungi of the *Cantharellaceae* family and *Cantharellus* genus, which co-habituates, being a symbiont of mycorrhiza (forming micorides on the roots of the trees) [13]. Mica formation is achieved through high glucose demand and due to good gas exchange with carbon dioxide. The sponge grows in

Romania, Bessarabia and Northern Bucovina in deciduous forests (under beech, oak), such as conifers, often on mussels and among blueberries, or through raspberries and blackberries from May to October (November) [14].
It has been reported by many investigators that the *Cantharellus* species have antioxidant potential as well as nutritional properties. Turkey, Bulgaria and Serbia are leading European countries regarding *Cantharellus cibarius* growth [15, 16].
It is highly appreciated for its wonderful, fruity, apricot-like flavor, and is highly prized for cooking throughout Europe. In addition to the aroma and smell, its texture is also pleasant.
The chanterelle is of great economical interest for northeastern Portugal, because its collection constitutes a way of subsistence for the residents, apart from becoming an important commercial source [17].
The aim of the work is the valorization of buttermilk enriched with mushroom proteins from the *Cantharellus cibarius* species in 3 different concentrations. Also, the paper presents the influence of the addition of mushroom powder by comparison with a normal sample of buttermilk on the rheological aspects.

MATERIALS AND METHODS

Materials

The materials used to make the products were:
- Raw milk - purchased from dairy farm located in Cârțișoara, Complex Albota, Sibiu; the raw milk was analyzed sensitively but also physico-chemical before being used;
- Blank sample - it was represented by buttermilk purchased from the supermarket;
- Cultures DVS - purchased from DR.Ch. Hansen;
- Mesophilic and aromatic lactic bacteria culture - for the fermentation of milk and obtaining the product with specific properties, it was fed with a mesophilic and aromatic lactic bacteria culture consisting of *Lactococcus lactis, Lactococcus cremoris* and *Lactococcus diacetylactis;*
- Mushroom from *Chantarelus cibarius* species - purchased from a naturist pharmacy.

Methods

Buttermilk preparation
Buttermilk was made under laboratory conditions from cow's milk. The raw milk was pasteurized at 85 - 95 °C for 20 minutes, cooled to 30 - 32 °C and then seeded.
The cultures were introduced into the milk, then the milk was thermostated at 30 - 32 °C for 7 hours, and finally the obtained dairy product was cooled to 6 - 8 °C. After that, the milk was enriched with mushroom powder of the chosen species [18].

Preparation of samples
From the simple buttermilk, after it was subjected to the seeding operation, 1 liter of the product was collected in 3 separate containers. In the first container, 10 g of mushroom powder were added, 15 g of mushroom powder in the second and 20 g of mushrooms in container number 3.

After the mushroom powder was added, the samples were thermostated in the same way as the blank sample and then cooled [19, 20].

Rheological evaluation

Knowledge of the rheological properties of food products is important for process design, evaluation and consumer acceptability of a product. Especially for products with time-dependent rheological properties, it is important to establish relationships between structure and flow behavior. Food products generally have a complex rheological character and their rheological behavior depends not only on temperature and composition, but also on shear stress, shear rate, shear time, as well as previous shear and thermal history [21 – 23].

Viscosity evaluation

Viscosity is what gives consistency and represents a quality indicator. Rheological measurements were performed for each sample at a temperature of 5 ± 2 °C using a rotational rheometer, the HAAKE 550 viscometer, model VT with concentric cylinder 500 with MV DIN sensor, with an inner radius of the outer cylinder of 21 mm, 19.36 mm radius and 58.08 mm inner cylinder length as we can see in Figure 1. The Haake Viscotester VT550 was connected to a PC with VT 500 software version 1.3. within the research laboratory of the faculty [24].

Figure 1. *Haake Viscotester VT550*

Statistical analysis

All physico-chemical determinations were statistically processed using the Minitab program. Minitab is a statistics package developed at the Pennsylvania State University by researchers Barbara F. Ryan, Thomas A. Ryan, Jr., and Brian L., [25]. Joiner in conjunction with Triola Statistics Company in 1972. It began as a light version of OMNITAB 80, a statistical analysis program by National Institute of Standards and Technology [25]. The program displays two main work windows: the session window with the analysis results and the work window intended for data entry, the worksheet being similar to the Excel one. Descriptive statistics summarize a range of data using specific values.

These descriptive statistics include:
- Mean = the arithmetic mean value of the data in the column;
- Standard deviation = measure of data dispersion;
- Median = central value of a series;
- Minimum = the smallest value in a series;
- Maximum = the highest value in a series.

RESULTS AND DISCUSSION

Rheological characterization

Figures 2 - 5 show the viscosity and shear rate curves for the buttermilk samples with the addition of mushroom powder.

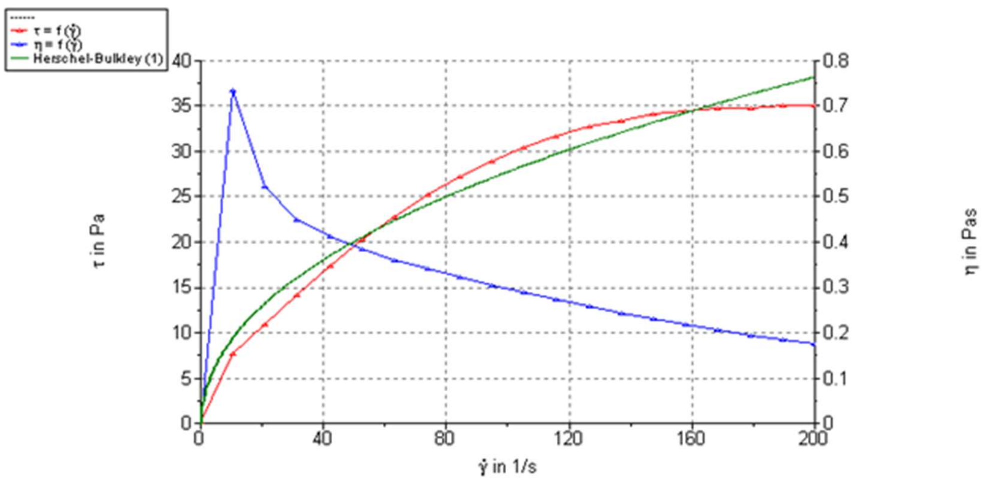

Figure 2. *Variation of viscosity and shear rate for the blank sample*

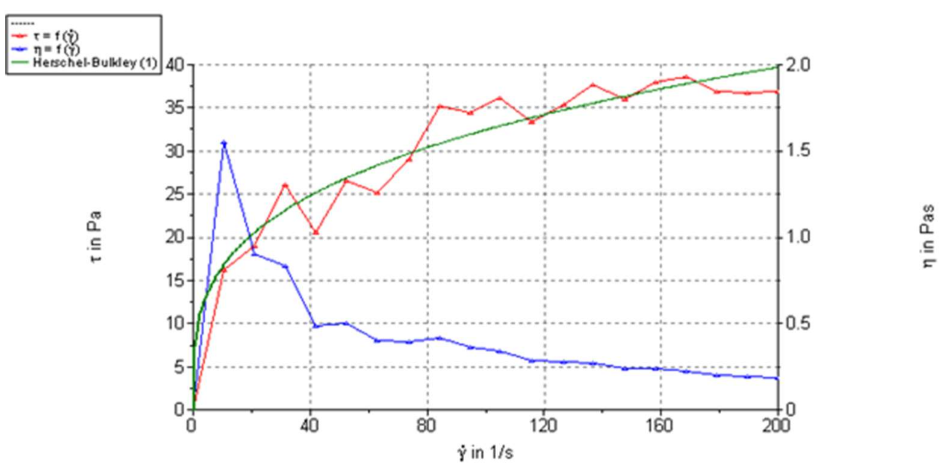

Figure 3. *Variation of viscosity and shear rate for the sample with 10 g of mushroom powder*

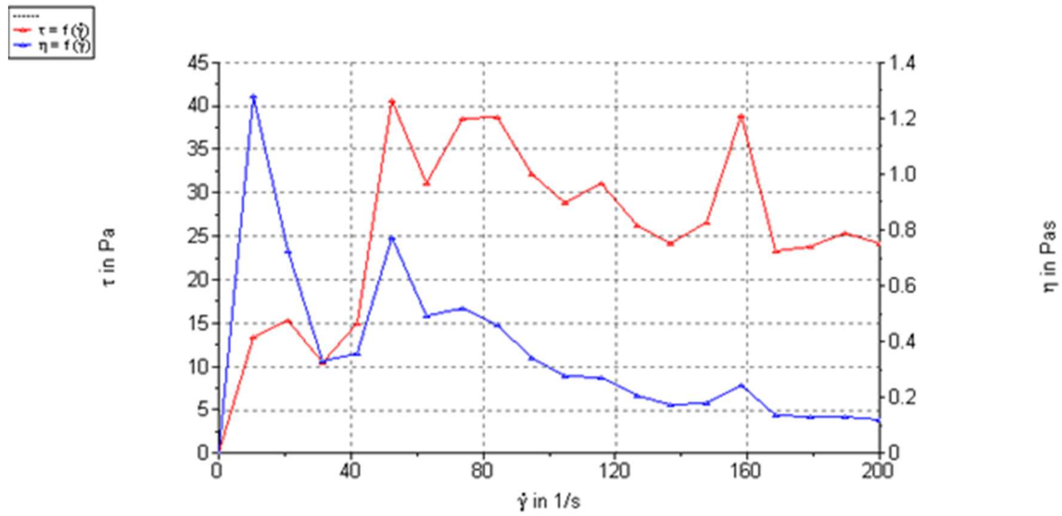

Figure 4. *Variation of viscosity and shear rate for the sample with 15 g of mushroom powder*

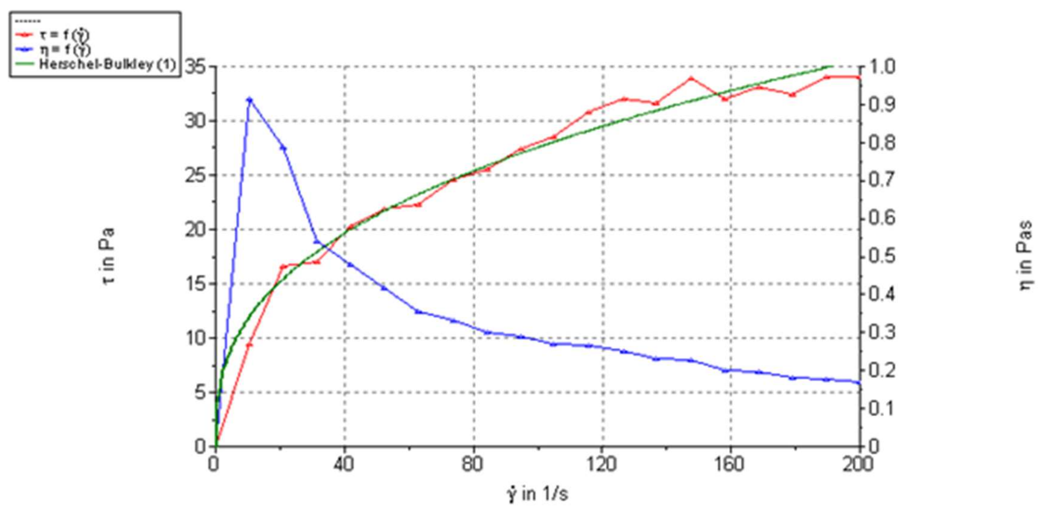

Figure 5. *Variation of viscosity and shear rate for the sample with 20 g of mushroom powder*

According to the graphs, viscosity values between 0.125 and 0.184 Pa·s were recorded. The values of the regression coefficient r for models adjusted for the viscosity curves are given in Table 1. The sample containing 15 g of mushroom powder has lower viscosity values than the control sample without addition. The highest viscosity was observed for sample 3 with 15 g of mushrooms powder.

Table 1. *Rheological models adjusted to the viscosity curves*

Sample	Herschel-Bulkley
blank sample (P1)	0.1741
buttermilk with 10g mushroom powder (P2)	0.1839
buttermilk with 15g mushroom powder (P3)	0.1250
buttermilk with 20g mushroom powder (P4)	0.1676

The samples were analyzed using the Haake Viscotester VT550 device (Figure 1) and the values presented in Table 2 were measured based on the Herschel-Bulkley model.

Table 2. *Herschel-Bulkley measured values*

Sample	τ [Pa]	γ [s^{-1}]	η [Pa·s]	T [°C]
P1	348.81	200	0.1741	21.85
P2	36.78	200	0.1839	22.39
P3	24.99	200	0.1250	22.28
P4	33.52	200	0.1676	21.94

where:
τ = yield stress (Pa);
γ = shear rate (s^{-1});
η = viscosity (Pa·s);
T = temperature (ºC).

To determine the time-dependent rheological behavior of the samples, the viscosity was recorded at a constant shear rate and a statistical analysis program was used to obtain the results. After submitting the buttermilk samples to a constant shear rate, the values presented in the graphs below were obtained.
As can be seen in Figure 6, the samples recorded different viscosity values on day 1. The values were recorded between 3.94 for the sample with 15g of mushroom powder and 0.3 for the blank sample. From the values obtained, it can be said that the addition of mushrooms influences the viscosity of the samples from the first day.

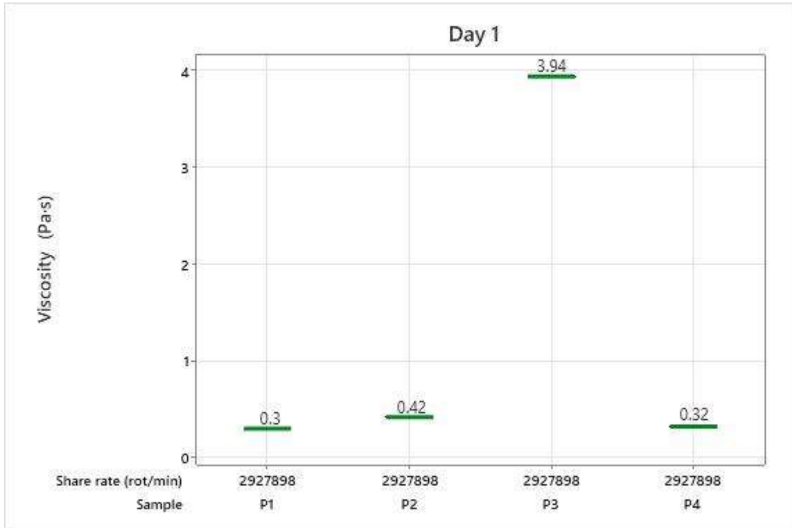

Figure 6. *Variation of viscosity to a constant shear rate for the 4 sample in day 1*

The graph from Figure 7 obtained on day 7 recorded increases in viscosity compared to day 1 for sample 2, and for the rest of the samples the values were slightly decreasing. The values were recorded between 0.39 for the sample with 10g of mushroom powder and 0.29 for the same sample as in day 1, namely the blank sample.

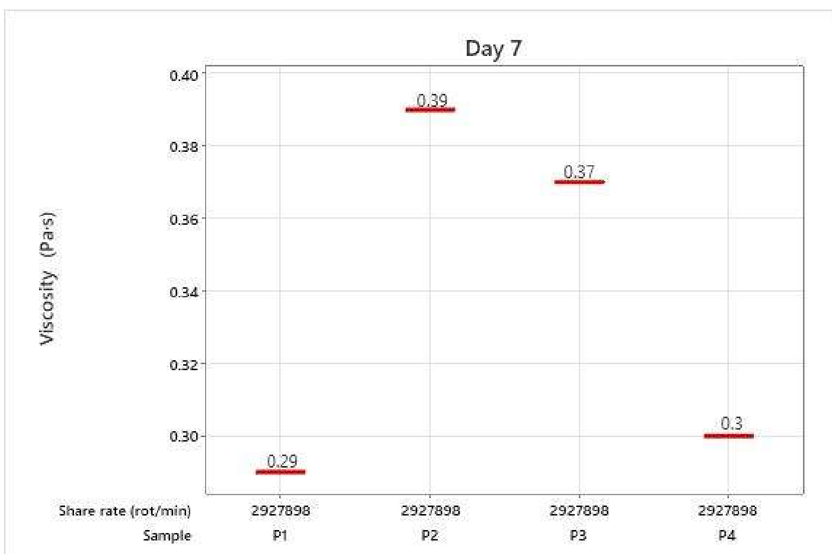

Figure 7. *Variation of viscosity to a constant shear rate for the 4 sample in day 7*

Figure 8 shows the viscosity values on day 14 of the 4 samples at the same constant share rate. As can be seen, the values are also decreasing compared to day 1 and day 7, sample 2 with 10g of mushroom powder still keeps its highest value of 0.36, but this is also decreasing compared to day 7. As in the other days, the lowest value of 0.27 was recorded for the blank sample.

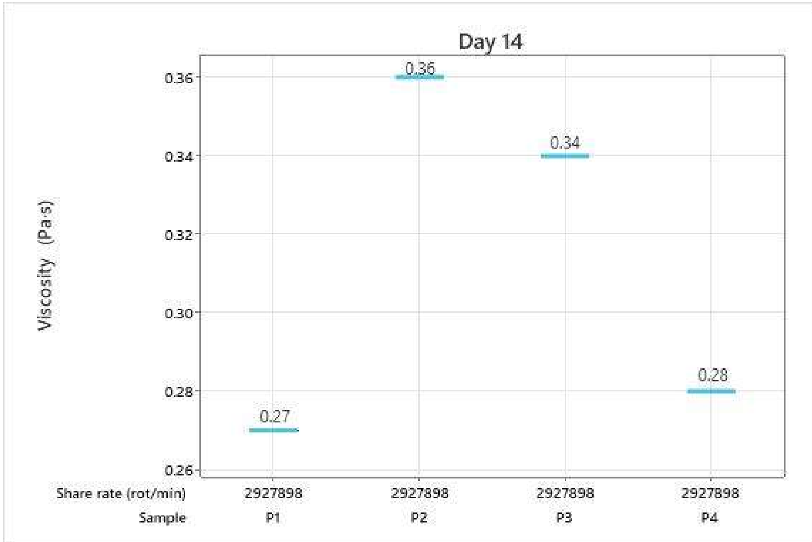

Figure 8. *Variation of viscosity to a constant shear rate for the 4 sample in day 14*

Discussions of modeling and rheological characteristics with results obtained by other authors

The rheological effects on dairy products in different forms have also been evaluated by other researchers. For example, the authors A. Dabija, G.G. Codină, together with others, studied the effects of adding vegetable proteins to yogurt [26].

The plant proteins studied were pea, soy protein, wheat gluten, hemp protein and pumpkin seed meal. The amount of vegetable protein added to the raw milk before pasteurization was calculated so that the yogurt contained 4 % protein. The results showed that the addition of vegetable protein in yogurt led to rheological, physico-chemical and sensory changes. The analysis revealed that there were no significant differences between samples with different vegetable protein additions and as a conclusion, vegetables could be a source of protein useful in the development of new products.

In another work, [27] the researchers Ofoli, Morgan and Steffe talk about a versatile four-parameter model is presented for the rheological characterization of inelastic fluid foods. It has been that the model provides improved capabilities for flexible and complete characterization of fluid foods. It also facilitates the development of generalized flow equations for fluid food analyses. The proposed model has the following key advantages: It removes the uncertainty usually associated with deciding what rheological model is best for a given fluid food, provides significant flexibility for improved characterization of complex food materials, enhances the potential for using rheological parameters as important quality control and process factors.

In the paper types of rheological behavior, a rheological model similar to this study described the variation of viscosity and shear stress for a series of yogurt samples enriched with chia seed powder.

Rheological measurements were performed for each sample at a temperature of 4 ± 2°C using a rotational rheometer. Low-fat yogurts prepared with chia seed powder showed higher viscosity values than the control sample without addition. The results suggest that the use of this powder, with gelling properties, contributes to increasing the firmness and viscosity of low-fat yogurt.

CONCLUSIONS

The samples of buttermilk show a decrease in acidity during the analyzed period, because during this time there is an increase in acidity that leads to the appearance of the phenomenon of syneresis (removal of whey) so that the product becomes more fluid. This syneresis is a normal phenomenon that does not influence the quality of the product. The quality standards stipulate a maximum amount of 2 % whey removal from the mass of the product for extra buttermilk type, 5 % for fat buttermilk type and 5 % for low-fat buttermilk type.

The obtained results showed that the addition of mushrooms added to the dairy assortments brings modifications of structure for all samples, and the results are observed in all 14 days.

The most obvious changes resulted for sample 2 with 10 g of mushroom powder in day 7 and day 14, and the lowest values were obtained for sample 4 with the highest content of mushroom powder were the changes where quite significant close to the blank sample according to the graphs.

In conclusion, the products obtained by the mixture of buttermilk and mushroom powder bring significant structural changes, and in higher concentrations the samples tend to balance their structure bringing it close to the control sample. At a concentration of 10 g of mushroom powder, the viscosity tends to increase rapidly, but by increasing the concentration of mushrooms, the viscosity begins to stabilize if the addition is made gradually.

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