World Journal of Advanced Engineering Technology and Sciences
eISSN: 2582-8266
Cross Ref DOI: 10.30574/wjaets
Journal homepage: https://wjaets.com/

(Research Article)

Check for updates

Optimizing the incorporation rate of xanthan gum in bread-making based on composite flours: The case of wheat-rice mixtures

LOPY Maurice Jean-François Sylvestre [1,*], DIOUF Abdou [1], SOW Mamadou Salif [1], DIAGNE Ndeye Wemsy [1] and DIOUF Vieux Diouma [2]

[1] *Institute of Food Technology (ITA), Route des Pères Maristes Hann, BP 2765 Dakar, Senegal.*
[2] *OLAM AGRI Sénégal.*

World Journal of Advanced Engineering Technology and Sciences, 2024, 11(01), 365–371

Publication history: Received on 15 January 2024; revised on 25 February 2024; accepted on 27 February 2024

Article DOI: https://doi.org/10.30574/wjaets.2024.11.1.0062

Abstract

This article studies how the incorporation of xanthan gum affects the rheological properties and baking characteristics of a mixture of wheat and rice flours, with an equal ratio of 50% each. Different incorporation rates of xanthan gum ranging from 0% to 1.5% were studied. These different blends' rheological and baking parameters were assessed using an alveograph and a Chopin volumeter. The results showed that the control sample, which contained no xanthan gum, had the poorest rheological and baking properties compared with the samples containing xanthan gum. The addition of xanthan gum considerably improved the rheological and baking properties of the composite flours. The sample with the lowest gum incorporation (0.25%) had the highest swelling index, as indicated by a working value (W) 160 10^{-4} J and had the highest specific volume (Vsp) 1.83 cm^3 /g, outperforming the other samples that contained more gum.

Keywords: Compound Flours; Xanthan Gum; Baking Properties; Rheological Properties

1. Introduction

African countries are the world's biggest importers of wheat, with over 45 million tones in 2013, representing a third of the continent's food imports (1). Consumer demand for wheat is growing faster, at 5.1% per year (2). Faced with these high imports, African countries are exposed to fluctuations in world prices, their currencies are severely weakened, and demand for local food products has fallen considerably, undermining all the measures put in place to combat food insecurity.

In Senegal, where bread consumption is higher than the average in Africa, bread is the most consumed product after rice. Around 5 million baguettes of bread are produced every day (3)**.** This trend would be acceptable if the raw material were available locally. The main difficulty in using tropical cereals in bread-making lies in the fact that their proteins do not form gluten, a viscoelastic protein compound, which gives the necessary quality for bread-making. Cereal flours that do not have this property have to be mixed with wheat flour. As a result, to continue eating bread, the Senegalese need to find a local substitute for gluten, hence the idea of using hydrocolloids such as xanthan gum.

Xanthan gum is a thickening additive that increases the viscosity of the dough for good gas retention and improves the sensory and technological quality of the dough (4; 5). The use of xanthan gum is one of the most promising processes for producing wheat-free bread (6). Rice, appreciated for its hypoallergenic properties and ease of digestion, has a high amylose content and less than 5% damaged starch (Guyral et al 2003; 8). Its pale color and flavor make it easy to incorporate into many products (9). Combined with xanthan gum, rice can therefore be a good alternative to imported wheat in the design of composite breads.

* Corresponding author: LOPY Maurice Jean-François Sylvestre.

This study aimed to optimize the incorporation of xanthan gum in the design of bread based on wheat/rice composite flours.

2. Material and methods

2.1. Plant and technical material

Rice grains of a variety produced in the valley were transformed into flour using a laboratory grain mill. Type 55 soft wheat flour, yeast and salt formed the basis of the raw materials used in the tests.

The xanthan gum used in this study was produced in the laboratory of the biotechnology division of the Institute of Food Technology Institute of Food Technology (ITA) in Dakar. The rheological and baking characteristics were determined using an alveograph and a Chopin

volumeter. The equipment used in a conventional bakery included a kneading trough, a rotary oven, and a proofing oven for bread-making tests.

2.2. Methods

2.2.1. Rheological characteristics

The rheological characteristics of the doughs, such as tenacity, elasticity, and strength, were determined using a Chopin alveograph in accordance with the standard (ISO27971:2023) (10). The procedure defines the formation of a dough of flour and salted water, without yeast, in a specific mixer. The kneading time and the water content of the dough are always constant. After kneading, the dough is rolled and cut into 5 small circular test tubes. Each test piece of dough is inflated until the bubble bursts. Five parameters are estimated: W, G, P, P/L. W represents the deformation work of the dough. It gives a good indication of the baking strength. The G, or swelling index, expresses the dough's extensibility. P is related to the dough's tenacity. The P/L ratio reflects the balance between tenacity and extensibility. The curves and alveographe parameters are calculated by the alvéolink, an automatic recorder-calculator that enables data to be acquired, displayed, and printed. The five curves are displayed simultaneously, and the mean curve is automatically plotted. The average of the various parameters is calculated and displayed.

2.2.2. Baking characteristics

Bread-making tests

The bread-making tests were carried out in accordance with the standard defined for composite flours (CEA, 1998) (11). The tests involved five main stages: kneading, kneading, shaping, final fermentation and baking. The different incorporation rates were added to 250g of rice flour and 250g of wheat flour (table 1).

Table 1 Variation in the incorporation rate of xanthan gum

Samples	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Xanthan(g) Gum	0	1,25	2,5	3,75	5	6,25	7,5
Rice Flour (g)	250	250	250	250	250	250	250
Wheat flour (g)	250	250	250	250	250	250	250

The tests were carried out under the same conditions. A laboratory mixer was used to mix the dough. The dough was then dotted for 20 minutes, followed by shaping in moulds and on trays. The dough pieces were fermented after one hour in a fermentation oven set at a temperature of 30°C. The dough pieces were baked in a rotary oven for 25 minutes at a temperature of 200°C.

2.3. Specific volume

The specific volume of loaves is calculated as the ratio of the volume V to the mass m.

$$V_{spécifique} = \frac{V}{m}$$

It is determined by means of a Chopin volumeter, according to the slightly modified method approved by AACC 10.05 (AACC, 2000) (12). The method is based on the displacement of sorghum grains in a container in which the manufactured bread is placed. After calibration with a control of 1800cm^3, the bread is introduced into a container placed on the central platform of the structure. The other container was filled to the brim with sorghum grains and the excess scraped off. The sorghum grains are poured upstream of the structure and fill the other container with bread until it overflows. The volume of grains overflowing corresponds to the volume of bread present in the structure and is read off at the graduated foot.

3. Results and discussion

3.1. Rheological characteristics

The Chopin alveograph is used to estimate the physical properties of pastes during the various mechanical manipulations. The results of the alveograph tests on the samples are shown in Figure 1.

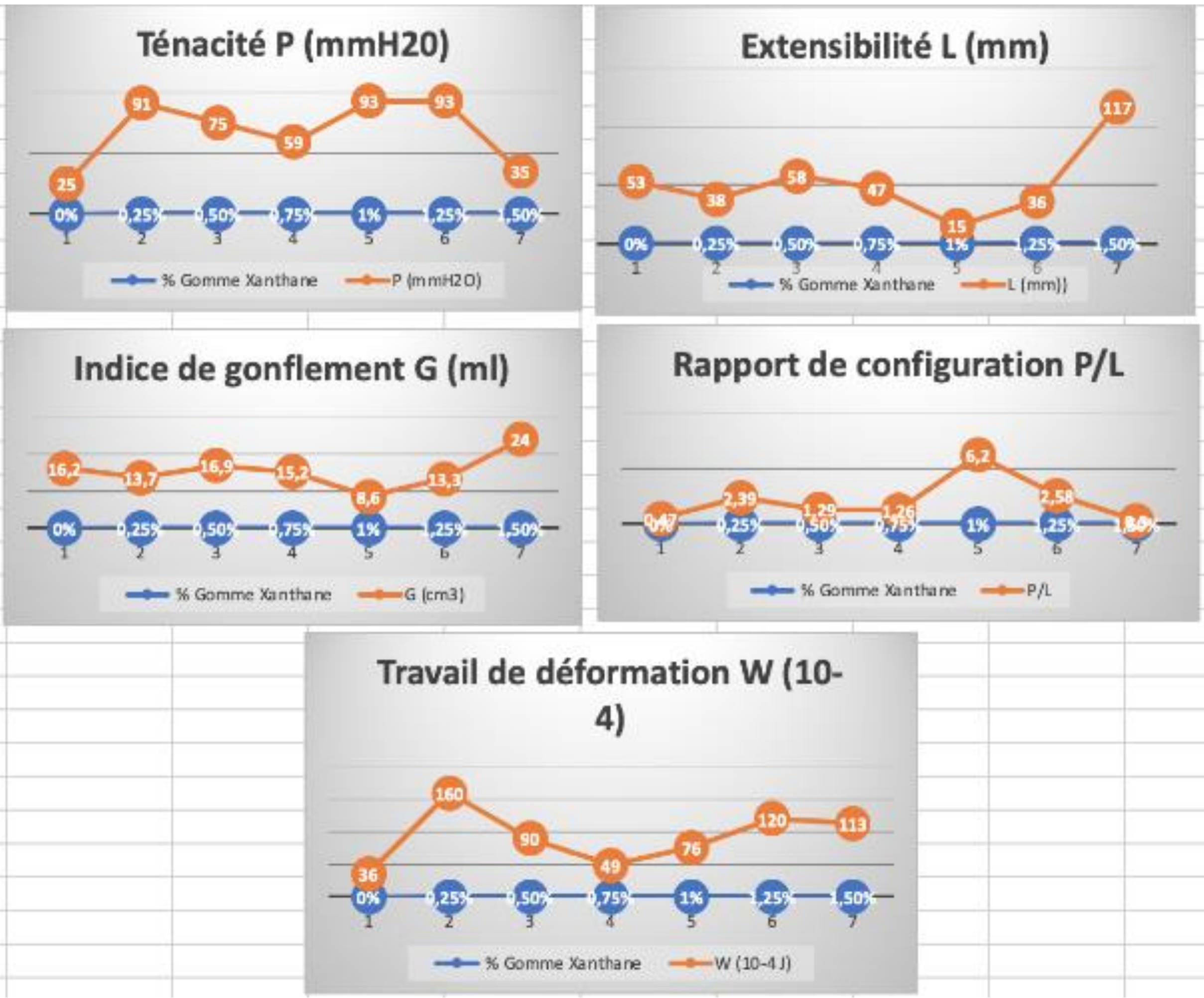
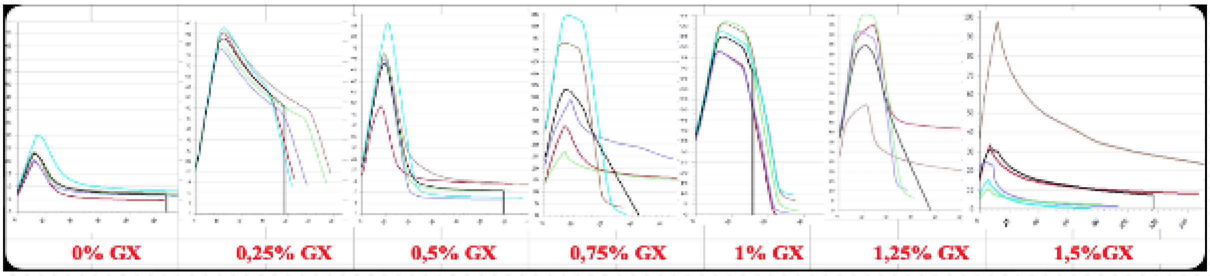


Figure 1 Variation in alveographic parameters as a function of gum incorporation rates.



The parameters P, L, G and W correspond to the average of the P, L, G and W of the five plots.

Figure 2 Alveograph results as a function of xanthan gum incorporation rate.

Xanthan gum has the effect of reinforcing the links between the proteins in the flour and therefore strengthening the structure of the dough (13). This property of the gum was observed in the results obtained with an increase in the P parameter of the alveograph, which is linked to the tenacity of the dough. Similar results were obtained by Rossel et al (14) and Shittu et *al* (15), who found that the addition of xanthan had significant effects on toughness.

In fact, the samples with xanthan gum are much tougher than the control sample without xanthan gum. Toughness indicates good baking strength and stiffness, which help to maintain the dough and air pockets (CO_2) (15). According to Roussel and Chiron (17), good tenacity is determined by a P between 60 and 80 mmH_2 O. A range obtained with all the samples except for the sample with 1.5% incorporation, which has a P of 35mmH_2 O. Consequently, gum incorporation up to a level of 1.25% increased the dough tenacity of the 50% wheat and 50% rice blends. Furthermore, according to the authors Bordes et al (18), the 0.25%, 1% and 1.25% blends, which have P values of 91, 93 and 93mm H_2 O respectively, can be classified as good quality wheat.

The P/L ratios of the samples with gum, varying between (1.29 and 6.2) are higher than that of the control (0.47). According to Rossel et al (14), who obtained similar results, this could be explained by a fortifying effect of the gum, probably due to a strong interaction between the gum and the flour proteins.

Regarding baking strength (W), which is the most widely used criterion as it summarizes all the other parameters, the samples with gum showed better results (49 to 160 10^{-4} J) than the control sample without gum (36 10^{-4} J). From 0.25%, the addition of gum had a negative linear effect on baking strength up to a level of 0.75% incorporation. For 50% rice flour, a flour that cannot be used to make bread, the results obtained fall into the category of insufficient W, as they are < 150 10^{-4} J. However, the sample containing 0.25% gum had a W = 160 10^{-4} J, which places it in the average category according to Roussel and Chiron (17) and in that of bread wheat with a W in the range (130-250) according to the I.S.O 27971:2008 standard on rheological characteristics using the alveograph (19).

3.2. Bread-making tests

Breadmaking trials are still the most objective way of assessing baking quality, as they enable a direct judgement to be made on the quality of the dough, but also on the quality of the bread obtained, with the appearance of the crumb and the volume (20; 21). The specific volume was determined on the loaves obtained.

3.3. Specific volume

Specific volume is one of the most important visual characteristics of bread. According to Hager and Arendt (22), it is a key parameter for assessing bread quality. Figure 3 shows the evolution of specific volume as a function of gum incorporation rate.

The results in Figure 3 show that the control sample without gum and the sample containing 1.5% gum had the lowest specific volumes in our study, i.e. 1.51cm3/g and 1.076cm3/g. This suggests that the gum acts by increasing the volume, but when the incorporation rate is greater than 1.25%, the volume decreases and is even lower than the control. Similar results were obtained by the authors Bojnanska et *al* (13) who stated that products with xanthan gum had a greater volume than products without this additive, which differs from Lazaridou et *al* (23) who saw no effect of the addition of gum on the specific volume.

The highest specific volume (1.85 cm3/g) was obtained with the sample with 0.25% gum incorporation, which happens to be the lowest level. This result corroborates those of Hager and *Arendt* (22), who found that gum influences bread properties at very low levels of addition. Nevertheless, the volumes obtained when gum is incorporated at 0.5%, 0.75%, 1% and 1.25% are respectively 1.57±0.005[e], 1.566±0.007[d], 1.591±0.01[c], and 1.584±0.01[b], volumes significantly higher than the specific volume obtained with the control which is 1.514±0.01[g] cm³ /g. The results differ from those of authors Vodovotz, (24) and Sabanis and Tzia, (25), who observed that for gluten-free mixes, the addition of higher levels of xanthan gum did not significantly affect the volume.

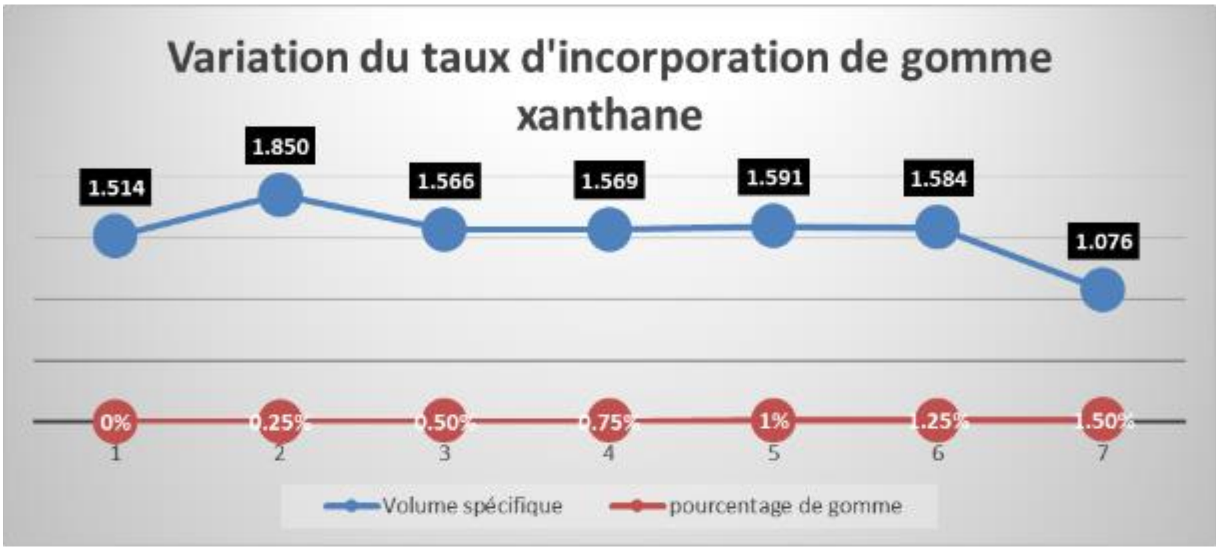


Figure 3 Changes in specific volume as a function of the rate of incorporation of xanthan gum.

Similarly, Mandala (26) found that the addition of xanthan gum above 0.16% resulted in a decrease in specific volume.

These divergent results could be explained by the fact that the gum behaves differently depending on the raw material. In fact, according to authors Hager and Arendt (22), the ability of xanthan gum to improve bread qualities depends on the formulation used, the chemical composition of cereals varies considerably, and certain ingredients can interact with the gum to varying degrees.

Figure 4 Bread shaped on trays

From 1.5% gum incorporation, a decrease in specific volume was observed. Peressini and Sensidoni (9) obtained similar results in mixtures with rice and buckwheat flour. However, at 1% they found no effect on specific volume. The same results were observed by the authors Sabanis and Tzia, (25) in their study with rice flour and maize starch, but the results for this incorporation rate are different from ours. This could be explained by the effect of xanthan gum on the properties of wheat flour-based pasta compared with other cereals.

Contrary to the findings of Park et al (27), our study gave different results regarding the impact of extensibility (L) on specific volume. We observed a negative correlation (r = -0.836) between specific volume and L, indicating that as volume increases, dough becomes less extensible.

Figure 5 Moulded bread

4. Conclusion

By introducing xanthan gum into the design of breads based on flours composed of a blend of 50% wheat flour and 50% rice flour, notable changes are produced in the rheological and baking properties of the bread. Improved parameters are recorded in the tenacity, baking strength and specific volume of the mixes. Tenacity increases up to a level of 1.25%. Among the different incorporation rates studied, the use of a minimum percentage of gum of 0.25% gives breads of satisfactory quality.

Given the challenges posed by high wheat imports, incorporating 50% locally sourced rice with a low gum content (0.25%) presents a viable alternative for promoting our local products.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Harold Macauley, Tabo Ramadjita. Cereal crops: rice, maize, millet, sorghum, and wheat. ICRISAT. 2015; 38.

[2] Nicole M. Mason, TS Jayne, and Bekele Shiferaw. Wheat consumption in sub-Saharan Africa: trends, determinants, and policy implications. December 2012; No 127

[3] FNRAA. Valorisation des céréales locales en panification, 2010 ; 41.

[4] Gambus, H., Sikora, M., Ziobo, R. The effect of hydrocolloid composition on the properties of gluten-free bread. Acta Scientiarum Polonorum. 2007; Vol 6, n°3, p 61-74.

[5] Gallagher, E. Gluten-free food science and technology. Oxford Wiley-Blackwell. 2009;256.

[6] Broutin C., Anen Totté, Emmanuel Tine, Martine François, Radolphe Carlier, Zacharie Badini Transforming cereals for new urban markets.2003; 295.

[7] GUJRAL H.S., GUARDIOLA I., CARBONELL J.V. and ROSELL C.M. Effect of cyclidextringlycosyl transferase on dough rheology and bread quality from rice flour. J. agricole. Food Chem (51). 2003; 3814-3818.

[8] Yano H. Recent practical research on the development of gluten-free breads. NPJ Sci. Food. 2019; 3 :7. 10.1038/s41538-019-0040-1

[9] Donatella Peressini, Alessandro Sensidoni. Effect of soluble dietary fibre addition on rheological and breadmaking properties of wheat doughs. Journal of cereal science. 2009

[10] NF EN ISO 27971Standard Cereals and cereal products - Common wheat (Triticum aestivum L.) - Determination of the alveographic properties of a dough at constant hydration of industrial or test flour and methodology for test milling. June 2023.

[11] ECA, Technical Manual on Compound Flours, Addis Ababa, Economic Commission for Africa, 1998. http://www.fao.org/inpho/fr

[12] AACC, 2000. American Association of Cereal Chemists. AACC Approved Methods (10th ed). American Association of Cereal Chemists, St Paul.

[13] Tatiana Bojnanska, Jana Smitalova, Alena Vollmannova. Effect of hydrocolloid addition on rheological and baking properties of spelt flour (triticum speltaL.) added products. Potravinarstvo, vol.10,2016, no.1, p.157-163

[14] C.M Rosell, J.A. Rojas, C. Benedito de Barber. Influence of hydrocolloids on dough rheology and bread quality. Food Hydrocolloid 15. 2001.p 75-81

[15] Shittu T.A., aminu R.A. and Abulude E.O. Functional effect of xanthan gum on composite cassava-wheat dough and bread. Food Hydrocolloids (23), 2009; 2254-2260.

[16] Bouhadi D, Kada I, Hariri A, Hemza B. Effect of adding malt flour on the functional and technological characteristics of soft wheat flour, June 2020.

[17] P. ROUSSEL and H. CHIRION, Les pains français : évolution, qualité, production, Science et technologie des métiers de bouche, ISSM, (2005) 1297 - 2606.

[18] Bordes J., Branlard F.X, Oury F.X., Charmet G., Balfourier F. Agronomic characteristics, grain quality and flour rheology of 372 bread wheats in a worldwide core collection. Journal of Cereal Science, 2008; vol.48, p.p. 569-579.

[19] ISO 27971: Method for the determination, by means of the alveograph, of certain rheological characteristics of pasta obtained from "soft" or "hard" wheat flour Triticum aestivum L. 2002.

[20] Feillet P. Le grain de blé : composition et utilisation. Institut National de la Recherche Agronomique, Paris. 2000; 308.

[21] Menkovska M., Knezevic D., Ivanovski M., Protein allelic composition, dough rheology and baking characteristics of flour mill streams from wheat. Cultivars with know and varied baking qualities. Cereal Chemistry.2002; vol 79, n.5, pp.720-725.

[22] Anna-Sophie Hager, Elke K. Arendt, Influence of hydroxypropylmethylcellulose (HPMC), xanthan gum and their combination on specific bread volume, crumb hardneś́s and crumb grain characteristics of gluten-free breads based on rice, maize, teff and buckwheat. 2012.

[23] LAZARIDOU A., DUTA D., PAPAGEORGIOU M., BELC N. and BILIADERIS C.G. Effects of hydrocolloids on dough rheology and bread quality parameters in gluten-free formulation. Journal of Food Engineering. 2007; (79) 1033-1047.

[24] R., Ie, P. and Vodovotz, Y. How xanthan and hydroxy propylated methylcellulose individually affect the physicochemical properties of a gluten-free dough model. Journal of food science, 2011;76(3), E274eE282.

[25] Sabanis, D. and Tzia, C. Effect of hydrocolloids on certain properties of gluten- free dough and breads. International food science and technology. 2011 ;17(4), 279.

[26] Mandala, I. G. Viscoelastic properties of starchy and non-starchy thickeners in simple mixtures or model foods. In de Vicente, J. *Viscoelasticity - From Theory to Biological Applications*, In Tech: Rijeka, Croatia, 2012; pp. 217-236, ISBN 978- 953-51- 0841-2. http://dx.doi.org/10.5772/50221

[27] Park S.H.,Bean S.R.,Chung O.K;,SEIB P.A. Levels of protein composition in hard winter wheat flours and the relationship to breadmaking. Cereal Chemistry, (2006). vol.83, n.4, p.p. 418-423.