
Influence of Coconut Fibre Inclusion on Rheological Properties of Composite Wheat-Cassava Flour Dough Using the Mixolab

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Abstract: Coconut (*Cocos nucifera*) is one of the tropical nut fruits containing high percentage of dietary fibre among plant foods that are beneficial to human health. Rheological characteristics measurements for wheat cassava flour blends with the inclusion of coconut fibre were studied using the Mixolab, the standard “Chopin+” protocol. The flour blends were substituted with different levels of coconut fibre (0%, 5%, 10%, and 15%) and wheat-cassava flour blend was used as control. The effects of added coconut fibre on the rheological properties of composite dough of wheat and cassava (90:10 w/w) were evaluated. The maximum torque during mixing (C1), the protein weakening based on the mechanical work and temperature (C2), the starch gelatinization (C3), the stability of the starch gel formed (C4), the starch retrogradation during the cooling stage (C5) were determined. Results showed that the torque values in all the dough decreased with the inclusion of fibre except in C1 and C2. The values of C1 and C2 (the dough development and the stability of proteins) increased with the increasing level of coconut fibre. Increasing level of fibre inclusion reduces the gelatinization of the cooked starch (C3), however 5% fibre dough (CNF) had the highest torque and the lowest torque was observed in 15% fibre dough (FPC), though the control sample (CTR) non fibre dough had the highest 2.15 Nm. Addition of fibre increased the dough stability from 6.60 to 8.58 minutes. It was observed that 15% fibre enriched (FPC) had the highest dough stability.

Keywords: Coconut Flour, Composite Flour, Mixolab, Rheological Properties, Dough Stability

1. Introduction

Coconut (*Cocos nucifera*) belongs to the family *Aracacea*. It is a versatile fruit with many uses and it is widely distributed throughout the tropics and subtropics [1]. Coconut grows in more than 90 countries of the world, with a total production of 62 million tonnes per year, however most of the world production is in tropical Asia [2]. Coconut fibre is from coconut residue, which is a by-product of coconut milk extraction. It is a naturally available good source of dietary fibre, low in digestible carbohydrates and free of trans fatty acid, hence its utilization as functional food ingredients for human consumption. In recent times, the addition of fibre to foods has gained popularity as a result increasing incidence of some diet related diseases. Recent studies indicated that

dietary fiber may prevent some health condition and diseases such as constipation, hemorrhoids, hypercholesterolemia and colorectal cancer [3; 4].

Rheological properties of dough are very important indices for product development in terms of product quality and process efficiency [5-8]. During the baking process, flour composites are subject to mechanical work and heat treatment that promote changes in their rheological properties [9]. The unique dough-forming and breadmaking property of wheat is attributed to gluten protein, which is formed when wheat flour is hydrated and subjected to mechanical shear. Substitution of wheat flour with non-wheat flour and fibre has been reported to reduce bread making potentials of wheat flour due to dilution and disruption of the rheological and mechanical properties of gluten [10-11], while on the other hand report showed that

addition of fibre can also improve technological properties of dough such as prevention of syneresis and modification of viscosity and texture of formulated foods [12-13]. Dietary fibers in foods particularly in baked products have been reported to cause undesirable results such as weak dough in breadmaking, poor viscoelastic property [14-17]. The influence of fiber from various cereals including rice bran on the rheological characteristic of dough from wheat flour on the quality of biscuit has been studied [18].

The Mixolab, device (introduced in 2004 by Chopin Technologies, accepted as the ICC standard method No. 173) is one of the latest test equipments used to determine the rheological quality of dough. It allows the characterization of the physicochemical behavior of dough when subjected to a dual mixing and temperature constraints. It measures in real time the torque (expresses in Nm) produced by mixing the dough between two kneading arms, where the dough is subjected to dual mixing and temperature constrains [6; 19-20]. The Mixolab technique allows the study of rheological parameters of flour in terms of (i) proteins quality by determining their water absorption, stability, elasticity, and weakening properties; (ii) starch behaviour during gelatinisation and retrogradation; (iii) consistency modification when adding additives, and (iv) enzymatic activity of proteases, amylases, etc [19; 21]. The Mixolab works with a constant dough weight to eliminate variation and ensure uniformity during mixing. It is also efficient in determining the rheological properties and developing products high in fibre regardless of their type or granulometry.

Several studies have been carried out to investigate the application of Mixolab in rheological testing of gluten-free flours, whole wheat flour and bran, and effect of different hydrocolloids and enzymes on the rheological behavior of flour [6; 22-23]. It's potential to determine the rheological behaviour of bread dough from white flour and whole meal was investigated [21]. Also, the device was explored to characterize the thermo-mechanical behaviour of wheat flours and to establish the correlations within rheological parameters of the wheat flour supplemented with different additives such as fungal α -amylase, fungal hemicellulase and fungal xylanase [24].

Therefore, this present study is aimed at investigating the effect of coconut fibre on the rheological properties of composite wheat-cassava flour blends using the Mixolab.

2. Materials & Methods

2.1. Source of Raw Materials

The Wheat Flour (WF) used was commercial baker's grade wheat flour milled by Nigeria Flour Mills (Golden Penny, Nigeria). High Quality Cassava flour was procured from Federal Institute of Industrial Research Oshodi pilot plant, Lagos Nigeria while the coconut used was also procured from a local market in Lagos, Nigeria.

2.2. Methods

Coconut fruits were sorted and processed to extract coconut milk and the resulting shaft/residue was washed thoroughly with boiling water to enhance complete removal of milk and oil from the shaft. It was drained, dried and ground using a grinder (model HL 3294/C Phillips) to obtain fine particles. The coconut fibre obtained was mixed with the composite flour of cassava and wheat at ratio 10:90 (w/w) at different level of inclusion (0%, 5%, 10% and 15%). All the measurements were performed using the Mixolab "Chopin+" protocol. The preparation and characterization of the dough was according to the standard method (ICC-Standard Method No. 173, 2006; AACC 54-60.01; adapted ISO 5530-1:1997). Dough rheological investigations were performed by Mixolab with the standard settings shown in Table I which simultaneously determines dough characteristics during the process of mixing at constant temperature, as well as during the period of constant heating and cooling.

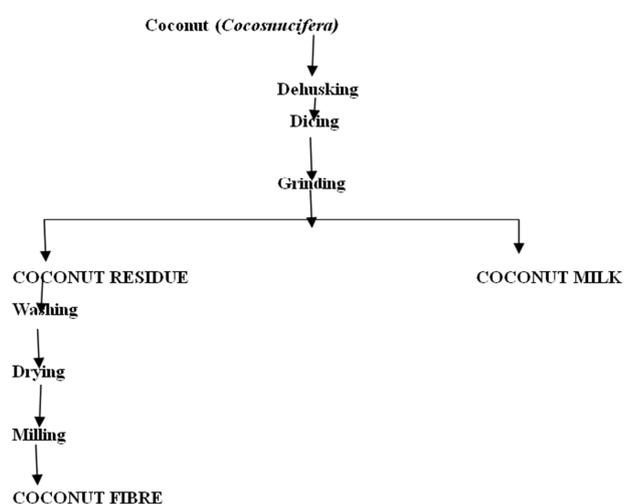


Figure 1. Flow chart for the production of coconut fibre.

This characteristic torque/time/temperature curve is divided into five distinct and important phases corresponding to the following:

C1 (Nm) – maximum torque (1.1 ± 0.05 Nm) during mixing;

C2 (Nm) – first minimum point on the curve and measures protein weakening based on the mechanical work and temperature;

C3 (Nm) – this is second maximum on the curve and it indicates starch gelatinization;

C4 (Nm) – is the second minimum point indicating the stability of the starch gel formed and amylase activity.

C5 (Nm) – is the last point on the curve and measures the starch retro gradation during the cooling stage;

α – represents the slope of the curve between the end of the period of 30°C and C2; gives indication about the rate of the proteins thermal weakening;

β – Represents the slope of the curve between C2 and C3; gives indications about the gelatinization rate;

γ – Represents the slope of the curve between C3 and C4; gives indications about the rate of amylase activity.

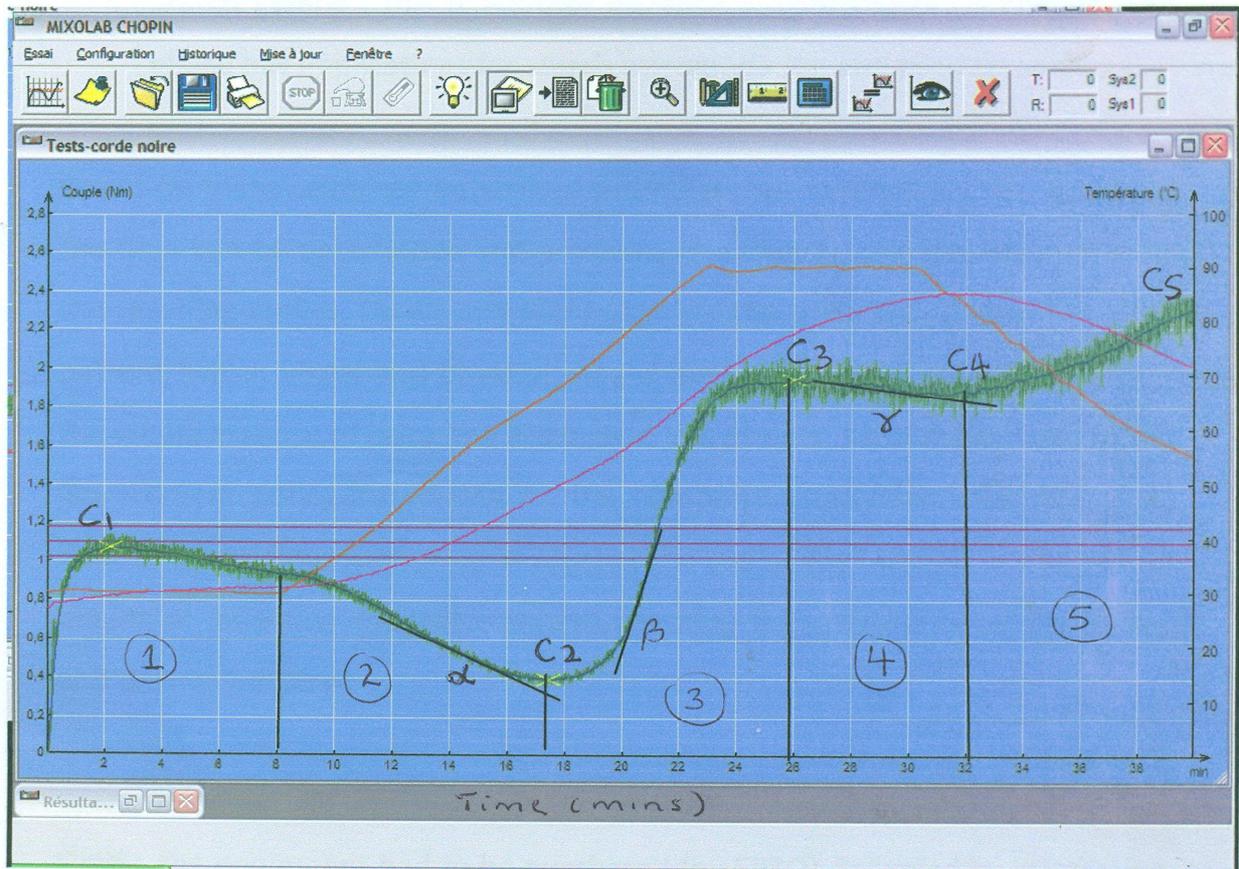


Figure 2. A standard Mixolab curve.

Table 1. Setting of the Mixolab.

Parameter	Value
Mixing rate (rpm)	80
Dough weight (g)	75
Tank temperature (°C)	30
Total analysis time (min)	45

Table 2. Percentage Composite Flour Formulation.

Flour blends	% LEVEL OF COCONUT FIBRE INCLUSION			
	0	5	10	15
Wheat flour	90	85	80	75
Cassava flour	10	10	10	10
Coconut fibre	0	5	10	15

Key: 0%-----CTR, 5%-----CNF, 10%-----CTP, 15%-----FPC

3. Results and Discussion

3.1. Rheological Characteristics

The results obtained from Mixolab measurement of dough are presented in Table 3. The C1 figures were all within the stipulated range of $1.10 \pm 0.05 \text{ Nm}$ and it is a constant temperature period at the start of the test, in which dough characteristics during mixing are measured.

C2 gives indication about the dough weakening due to protein unfolding which is coupled with torque increase. It ranged from 0.32-0.44 Nm. Coconut fibre is from vegetable which does not have gluten at all. The dough substitution with coconut fibre changed dough elasticity significantly during mixing and heating ($p < 0.05$) significantly. As the level of fibre inclusion increases, the more is the thermal protein network weakening, hence the dilution effect of the fibre on the dough which consequently reduced the dough consistency. However, the control sample (CTR) non fibre dough had 0.36 Nm.

The values of C1 and C2 (the dough development and the stability of proteins) increased with the addition of coconut fibre, but the greatest increase is in 15% level of inclusion.

C3 indicates starch gelatinization, this is referred to the cooking and the heating stage which describes the starch behavior and it is characterized by the gelatinized ability of the starch. It ranged from 1.59-1.47 Nm.

Results showed that the torque values in all the dough decreased with the inclusion of fibre. Increasing level of fibre inclusion reduces the gelatinization of the cooked starch, however 5% fibre dough (CNF) has the highest torque and the lowest torque was observed in 15% fibre dough (FPC), while the control sample (CTR) non fibre dough had the highest 2.15 Nm. These results are in accordance with the results of [25] that used wheat bran from 3-30%.

The amylase activity and the physical breakdown of the starch granules are associated with a reduction in the viscosity in the fourth stage. The torque C4 gives indication about the rate of enzymatic hydrolysis and the C4 dough's values showed a decrease in value from 5% to 10% fibre inclusion, but at 15% fibre inclusion an increase in C4 value was observed. This irregular trend could be due to the fact that coconut fibre is not from grain mantle that contains large quantity of α -amylases that is actually responsible for reduction of C4 values.

The torque (C5) is an indication of retrogradation. It decreased with the addition of fibre from the CTR -control sample (2.28 to 0.00 Nm) to 10% fibre inclusion (CTP). The dough with 15% of coconut fibre (FPC) is the strongest with

2.11Nm amongst the fibre enriched dough during starch retrogradation time in the cooling period. This was in accordance to the results of [26] that have enriched flour with different fiber, like fibrulin, fiberx, exafine and swelite, in various reports. Report showed that fibre inclusion implied better shelf life.

Amplitude: This is the curve width at C1 and indicates protein quality or elasticity of the dough. The higher the figure, the more elastic is the dough. It varies from 0.09-0.13 Nm with the highest value in 15% fibre enriched (FPC).

Development time and stability values are indicators of flour strength, thus higher values suggesting performance of stronger dough when coconut fibre is added.

Table 3. Mixolab Characteristics of the Composite Dough Blends.

Sample code	C1	C2	C3 (Nm)	C4	C5	α (Nm/min)	B (Nm/min)	γ (Nm/min)	Amplitude (Nm)	Stability (min)	WA (%)
CNF	1.08	0.32	1.59	1.28	1.70	-0.05	0.238	-0.046	0.09	6.60	73.2
CTP	1.09	0.37	1.51	0.31	0.00	-0.082	0.408	-0.838	0.09	7.93	71.2
FPC	1.15	0.44	1.47	0.51	2.11	-0.084	0.294	-0.172	0.13	8.58	70.9
CTR	1.13	0.36	2.15	1.83	2.28	-0.01	0.574	-0.026	0.09	1.80	60.9

*Values are means of triplicate determinations

Key: CNF-5% Coconut inclusion, CTP-10% Coconut inclusion, FPC- 15% Coconut inclusion and CTR-No coconut inclusion

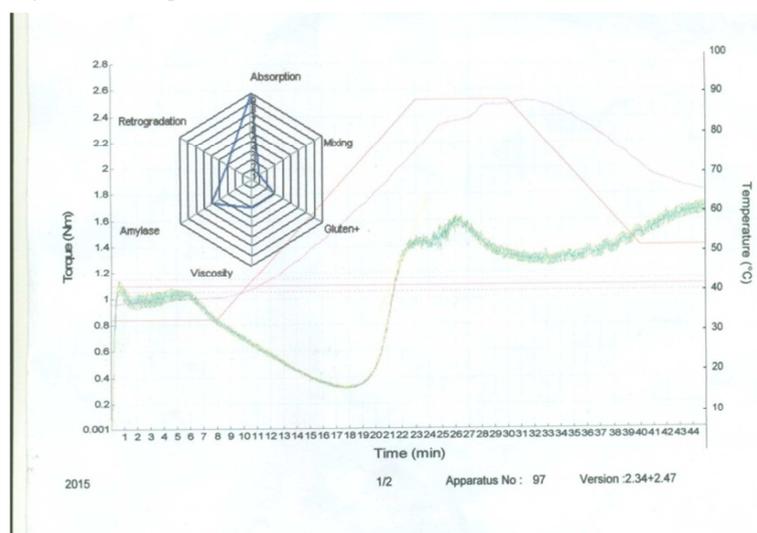
3.2. Effect of Coconut Fibre on Dough Stability

Dough stability is the time (in minutes) when the torque exceeds C1 and is a measure of dough resistance to kneading. The higher the figure, the stronger is the dough. Results showed that with increasing level of fibre addition, dough stability increases (Fig 5). Inclusion of fibre increases the dough stability from 6.60 to 8.58 minutes, while the control sample has 1.80 minutes. It was observed that 15% fibre enriched (FPC) had the highest dough stability. This is as a result of increased interaction of hydrogen connections including hydroxides groups present in fibre molecules. Dough stability is related to the quality of the protein matrix, which is easily damaged by the incorporation of other

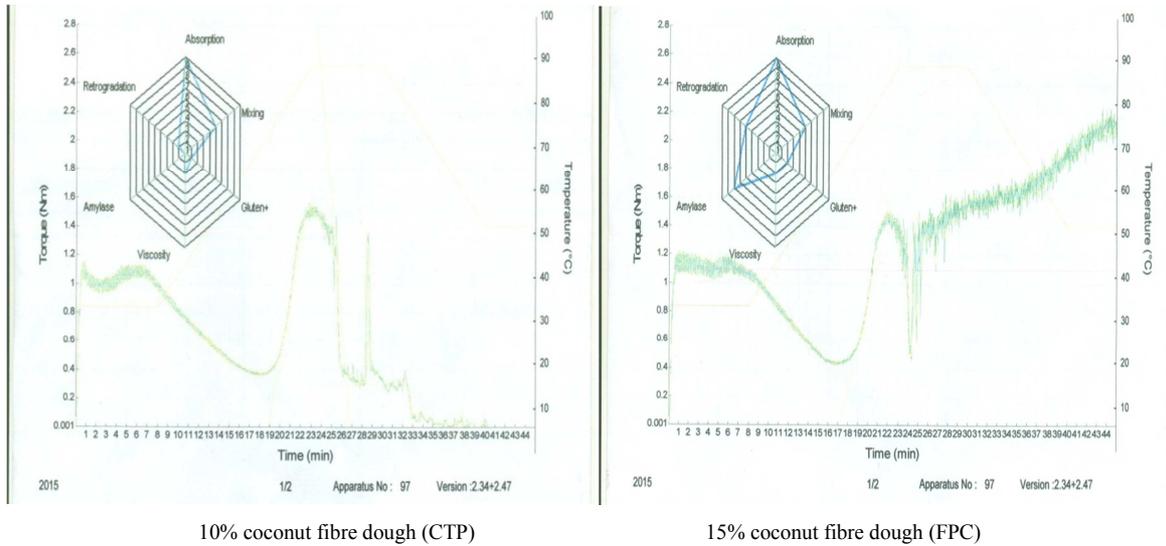
ingredients [27]. The results are in accordance with the results of other researchers that have used different types of fibers [17]

3.3. Effect of Coconut Fibre Inclusion on Dough Water Absorption (%)

Water absorption is the quantity of water required to obtain C1=1.1± 0.05. It ranged from 60.9-73.2 % with the highest value in 5% fibre inclusion (CNF) and the lowest in the control sample (CTR) which is the non fibre enriched flour blends (Fig 5). It decreases with increased level of fibre inclusion from 5%-15%. Water absorption is an important dough property as it has effect on bread quality and its shelf life.

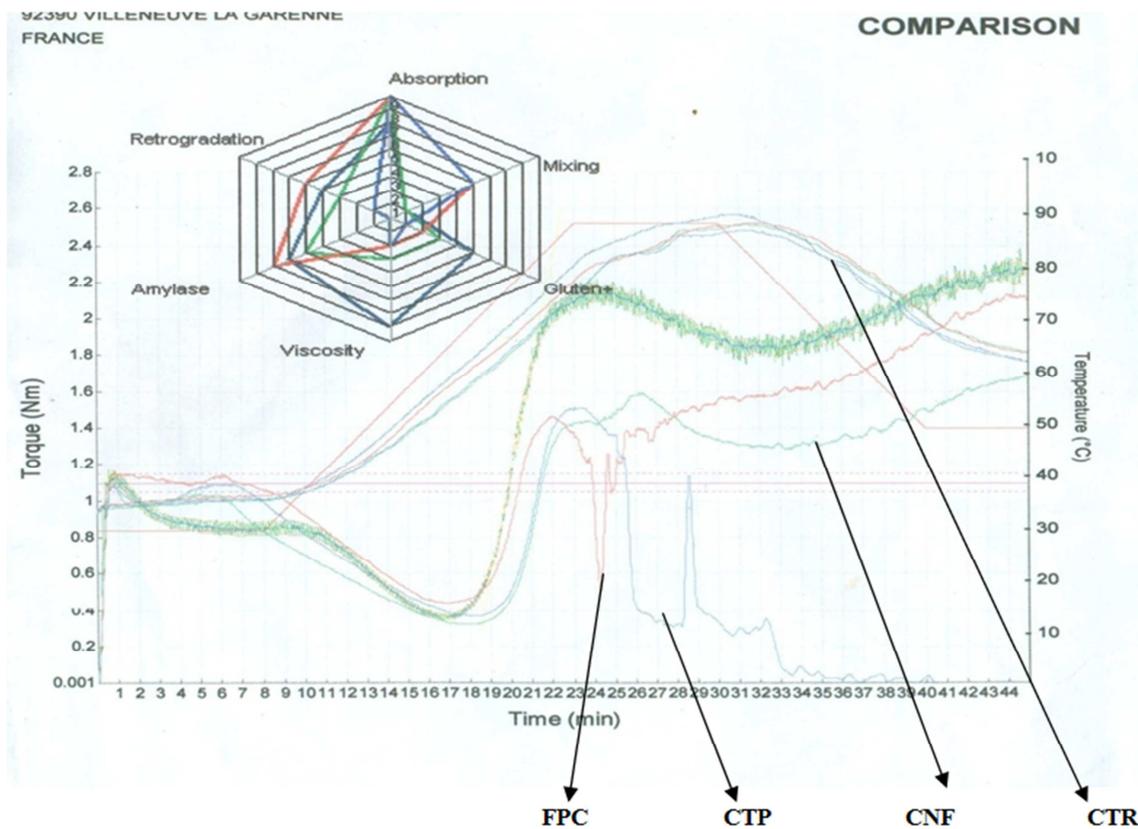


5% coconut fibre dough (CNF)



10% coconut fibre dough (CTP)

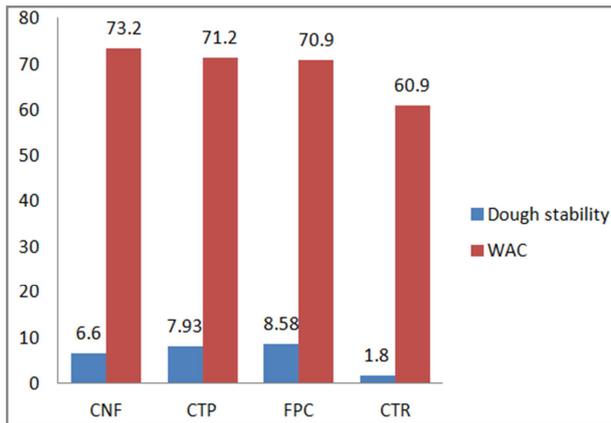
15% coconut fibre dough (FPC)

Figure 3. Mixolab curves of analyzed dough samples.**Figure 4.** Mixolab curves obtained for different levels of coconut fibre dough.

4. Conclusion

The Mixolab is a new equipment which measures the dough torque associated with mixing and temperature constraints and it is noteworthy that this Mixolab can be used as a substitute to other quality tests to envisage the protein and starch properties within a short period of time of 45 minutes, as well as an efficient equipment to predict the bread making quality of wheat flours based on dough stability and C2 values. It was

observed from the results that the influence of coconut fibre on the composite flour was significant leading to a weakening of the gluten network of the dough with good effects on its rheological properties. This study revealed that the higher the level of coconut fibre addition, the lower the dough water absorption, with 15% fibre- enriched dough (FPC) having the lowest water absorption value(70.9%) and increased level of fibre addition resulted in increased dough stability from 6.60-8.58 minutes with 15% fibre- enriched dough (FPC) having the highest dough stability.



Key: CNF---5% Coconut fibre, CTP----10% Coconut fibre, FPC----15% Coconut fibre, CTR---- 0% Coconut fibre

Figure 5. Effect of coconut inclusion on dough stability(mins) &water absorption (%).

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