Influence of moringa seed flour supplementation on the pasting properties of sweet potato-based tapioca grits

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Abstract

This study aimed to evaluate the influence of moringa seed flour (MSF) inclusion on the pasting properties of sweet potato-based tapioca grits. The MSF (2-10%) was properly blended with the sweet potato starch (SPS) (90-98%), using the ratios derived from the Central Composite Rotatable Design of the Design-Expert Software. Each blend of the SPS and the MSF, 100%SPS, and 100%cassava starch (CS) were separately toasted for 20 min at between 120 ^{o}C-150 ^{o}C, after which their pasting properties were determined using a standard method. The results depict that the pasting properties of the CS tapioca were significantly ($p<0.05$) higher than that of the SPS tapioca except in the peak and breakdown viscosities, where the SPS tapioca was significantly higher. The addition of the MSF increased the peak viscosity of the SPS tapioca from 333 RVU to 426 RVU in 98%SPS:2%MSF and reduced it to 202 RVU in 98%SPS:10%MSF. Conversely, the breakdown viscosity of the SPS tapioca reduced generally with the inclusion of the MSF from 171 RVU to 29 RVU in the 98%SPS:10%MSF. Also, there was a general increase in the trough, final, and setback (except 98%SPS:10%MSF) viscosities, as well as the peak time and pasting temperature of the SPS tapioca substituted with the MSF. Therefore, the addition of MSF in the production of the SPS tapioca grits increases most of the pasting properties, which may allow consumers to choose based on the level of viscosity preferred. However, the pasting temperature of all the tapioca grits was generally lower than the boiling point of water; hence the tapioca grits can form gruel in hot water below the boiling point and less than 6 min. This, at a commercial level, is a remarkable cost saving in terms of energy used.

Keywords: Sweet potato starch tapioca, moringa seed flour, cassava starch tapioca, pasting properties,

Introduction

Sweet potato has become a research focus due to its versatility and adaptability to variation in climatic conditions. Its versatility ranges from cooking, roasting, sparri production, confectionaries, flour, crisps, animal feed, starch, sweet potato beer, and sweet potato beverages to pounding (Egeonu, 2004). But there is presently little or no information on the use of sweet potato starch for tapioca production. Since, cassava and sweet potato are traditional staples known to be particularly attractive to low-income people not only because of their nutritive and caloric values and contribution to livelihood systems but also their adaptability to a wide range of growing conditions and low susceptibility to drought (Egeonu, 2004), the possibilities of producing cassava known product (tapioca) from sweet potato may be feasible. However, products developed from root and tubers are deficient in protein, micronutrients, and macronutrients; hence, the need for supplementation with moringa seeds in the form of flour. It is envisaged that the supplementation of tapioca grits produced from sweet potato starch with moringa seeds flour aside from being nutritious may affect the pasting properties, which are very important in the viscosity of the product. Therefore, this study aimed to evaluate the influence of moringa seed flour (MSF) supplementation on the pasting properties of sweet potato-based tapioca grits.

Materials and Methods

The sweet potato tubers were bought from a local market in Ilorin and processed into SPS using the modified method of Awoyale et al. (2019) and the moringa seed was processed into MSF using Oluwole et al. (2013) method. The MSF was properly blended with the partially dewatered SPS of particular moisture content. The blending ratios were determined using Design-Expert (Version 6.0), with the SPS ranging from 90-98%, and the MSF 2-10%. Each blend of the SPS and the MSF, 100%SPS and 100%cassava starch (CS) were separately

toasted for 20 min at 120 °C-150 °C, after which their pasting properties were determined using a standard method (Adebowale et al., 2008).

Results and Discussion

The pasting properties of the tapioca grits are important in predicting the behaviour of the gruel during and after cooking since it would be reconstituted in hot water before consumption (Adebowale et al., 2008). Table 1 shows the pasting properties of SPS tapioca grits and that of 100%CS. The mean of the pasting properties of the tapioca grits is peak viscosity 330.46 RVU, trough viscosity 231.08 RVU, breakdown viscosity 94.74 RVU, final viscosity 337.86 RVU, setback viscosity 109.72, peak time 5.09 min and pasting temperature 76.72 °C ($p<0.05$). All the pasting properties of the CS tapioca grits were higher than that of the SPS except for the peak (332.88 RVU) and breakdown (170.84 RVU) viscosities, which were higher than that of the CS. There was a general increase in the trough, final, and setback (except 98%SPS:10%MSF) viscosities, as well as the peak time and pasting temperature of the SPS tapioca substituted with the MSF.

The peak viscosity is the maximum viscosity, developed during or soon after the heating portion of the pasting test. It also indicates the viscous load likely to be encountered during mixing in the preparation of the tapioca grits into gruel (Adebowale et al., 2008). This implied that SPS tapioca grits might be more viscous than the CS tapioca when prepared into a gruel for consumption because of its high peak viscosity. Similarly, tapioca grits produced from 98%PS: 2%MSF (426.17 RVU) may be more viscous compared to that produced from 98%SPS: 10%MSF (201.92 RVU). The peak viscosity reported for 100% CS and tiger-nut enriched tapioca grits by Adeoti et al. (2017) was lower compared to that of this study. On the contrary, the peak viscosity of 100% CS tapioca grits reported by Adebowale et al. (2008) and Otegbayo et al. (2013) was higher than that of this study. The peak viscosity of the CS tapioca grits was not significantly different ($p>0.05$) from that of 99.66%SPS: 6%MSF, 90%SPS:10%MSF, and 94%SPS:11.66%MSF.

During the holding period of a typical pasting test, the sample is subjected to a period of constant temperature (usually 95 °C) and mechanical shear stress. This further disrupts the starch granule, and amylose molecules generally leach out into the solution and align in the direction of the shear (Adebowale et al., 2008). The period is called the trough viscosity. The trough viscosity measures the ability of the paste to withstand breakdown during cooling (Newport Scientific, 1998). This means that tapioca gruel prepared from CS may withstand breaking down during cooling compared to that of the SPS, due to its high trough viscosity. Similarly, tapioca gruel prepared from 94%SPS: 0.34%MSF (302.71 RVU) may withstand breakdown during cooling compared to that of 98%SPS: 10%MSF (173.34 RVU). The trough viscosity of all the tapioca grits in this study was higher than that reported by Otegbayo et al. (2013) for soy-flour enriched tapioca grits and tiger-nut enriched tapioca grits reported by Adeoti et al. (2017).

The breakdown viscosity reflects the ability of the sample to withstand shear stress and heat during cooking. The higher the breakdown viscosity, the lower the ability of the sample to withstand heating and shear stress during cooking (Adebowale et al., 2005). This implied that tapioca gruel from SPS (170.84 RVU) might not withstand heating and shear stress during cooking due to its high breakdown viscosity compared to that of CS with low breakdown viscosity (50.80 RVU). Similarly, the gruel produced from 98%SPS: 10%MSF (28.59 RVU) tapioca grits may withstand heating and shear stress during cooking compared to that of 98%SPS: 2%MSF (164.17 RVU) tapioca grits. It is of interest to add that the breakdown viscosity of the CS tapioca grits is not significantly different ($p>0.05$) from that of 99.66%SPS: 6%MSF, 90%SPS: 10%MSF and 94%SPS: 11.66%MSF.

Final viscosity is the most used parameter to determine a particular starch-based sample quality as it indicates the ability of the material to form a gel after cooking Adebowale et al., 2008). The low final viscosity observed for the SPS tapioca grits (228.08 RVU) compared to the peak viscosity indicate their low tendency to retrograde (Moorthy, 2002), which may not be the case for the CS tapioca grits (354.38 RVU) with higher final viscosity. Similarly, the high final viscosity observed in 94%SPS: 0.34%MSFtapioca grits (456.59 RVU) may lead to a higher tendency of retrogradation of the gruel, compared to that of 98%SPS: 10%MSF (229.42 RVU) with

lower final viscosity. The final viscosity of the CS tapioca grits was not significantly different ($p>0.05$) from that of 94%SPS: 6%MSF and 88.34%SPS: 6%MSF. The final viscosity of tapioca grits from different cassava varieties and roasting methods reported by Adebowale et al. (2008) was within the range of values reported in this study.

The viscosity after cooling to 50°C represents the setback or viscosity of the cooked paste. It is a stage where retrogradation or re-ordering of starch molecules occurs. Lower setback viscosity during the cooling of the paste indicates greater resistance to retrogradation (Sanni et al., 2004). This means that tapioca gruel prepared from the SPS tapioca grits (66.04 RVU) may resist retrogradation compared to that of CS tapioca grits (133.30 RVU). Also, tapioca gruel made from 98%SPS: 10%MSF tapioca grits (56.09 RVU) may withstand retrogradation because of its low setback viscosity compared to that of 94%SPS: 0.34%MSF (153.88 RVU) with higher setback viscosity. Similar setback viscosity to that of the CS tapioca grits was observed in those of 94%SPS: 6%MSF, 98%SPS: 2%MSF, and 90%SPS: 2%MSF, since there was no significant difference ($p>0.05$) in their setback viscosities.

When starch or starch-based foods are heated in water beyond a critical temperature, the granules absorb a large amount of water and swell to many times their original size. Over a critical temperature, which is the characteristics of a particular starch, the starch undergoes an irreversible process known as gelatinization. When the temperature rises above the gelatinization temperature, the starch granules begin to swell, and viscosity increases on shearing. The temperature at the onset of this rise in viscosity is known as the pasting temperature (Adebowale et al., 2008). The pasting temperature is also a measure of the minimum temperature required to cook a given food sample, which may have implications for the stability of other components in a formula and indicate energy costs (Newport Scientific, 1998). The temperature required to cook the SPS tapioca grits (57.40 ^{o}C) into gruel was lower compared to that of the CS tapioca grits (77.85 ^{o}C). Besides, the temperature required to cook the SPS-MSF tapioca grits into gruel was higher at 94%SPS: 6%MSF (82.40 ^{o}C) and lower than that of 90%SPS:10%MSF (59.45 ^{o}C). The pasting temperature of tapioca grits from different cassava varieties and roasting methods reported by Adebowale et al. (2008) and the soy-flour enriched tapioca grits reported by Otegbayo et al. (2013) were within the range of values of the present study, though the pasting temperature of the CS tapioca grits of this study was higher. Most of the values reported for the pasting temperature of tiger-nut enriched tapioca grits and that of the 100% CS reported by Adeoti et al. (2017) was higher compared to that of this study. The differences in the pasting temperature might be attributed to the varieties and different methods of the partial gelatinization of starch granules during roasting (Adebowale et al., 2008). However, the pasting temperature of all the tapioca grits was generally lower than the boiling point of water; hence the tapioca grits can form gruel in hot water below the boiling point and less than 6 min. This, at a commercial level, is a remarkable cost saving in terms of energy used.

Conclusion

The pasting properties of the CS tapioca were significantly higher than that of the SPS tapioca except in the peak and breakdown viscosities, where the SPS tapioca was significantly higher. The addition of the MSF increased the peak viscosity of the SPS tapioca in 98%SPS:2%MSF and reduced it in 98%SPS:10%MSF. Conversely, the breakdown viscosity of the SPS tapioca reduced generally with the inclusion of the MSF from in the 98%SPS:10%MSF. Also, there was a general increase in the trough, final, and setback (except 98%SPS:10%MSF) viscosities, as well as the peak time and pasting temperature of the SPS tapioca substituted with the MSF. Therefore, the addition of MSF in the production of the SPS tapioca grits increases most of the pasting properties, which may allow consumers to choose based on the level of viscosity preferred. However, the pasting temperature of all the tapioca grits was generally lower than the boiling point of water; hence the tapioca grits can form gruel in hot water below the boiling point and less than 6 min. This, at a commercial level, is a remarkable cost saving in terms of energy used.

Acknowledgment

The authors appreciate those who assisted in the roasting of the tapioca grits.

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Table 1. Pasting properties of sweet potato-based tapioca grits and that of cassava starch

Tapioca samples	Peak viscosity (RVU)	Trough viscosity (RVU)	Breakdown viscosity (RVU)	Final viscosity (RVU)	Setback viscosity (RVU)	Peak time (min.)	Pasting Temperature (°C)
98%SPS:10%MSF	201.92±0.35e	173.34±0.94h	28.59±0.59g	229.42±0.71f	56.09±0.23f	5.90±0.04a	81.53±0.04a
90%SPS:2%MSF	407.38±1.12a	271.08±2.12b	136.29±1.00b	401.42±1.29b	130.34±0.83b	4.64±0.05de	79.43±0.53a
99.66%SPS:6%MSF	256.88±3.01d	204.09±0.59g	52.79±3.59f	281.21±3.71e	77.13±4.31e	5.44±0.05b	81.10±0.49a
88.34%SPS:6%MSF	323.21±4.42c	234.50±2.94e	88.71±1.47de	343.54±4.54c	109.05±1.59cd	5.00±0.00c	79.80±0.07a
94%SPS:0.34%MSF	417.63±2.54a	302.71±1.71a	114.92±0.83c	456.59±2.35a	153.88±0.64a	4.77±0.05cd	78.63±0.67a
98%SPS:2%MSF	426.17±0.71a	262.00±1.06c	164.17±1.77a	384.13±7.36b	122.13±8.42bc	4.44±0.05e	78.20±0.00a
94%SPS:6%MSF	355.08±11.80b	248.09±3.78d	94.80±2.58d	355.18±16.18c	117.60±11.16bc	5.39±0.20b	82.40±3.30a
90%SPS:10%MSF	270.21±3.01d	200.34±1.89g	69.88±4.89ef	312.17±5.66d	111.84±7.54cd	4.87±0.00cd	59.45±4.38b
94%SPS:11.66%MSF	273.38±3.36d	203.17±0.47g	70.21±2.89ef	301.17±5.89de	98.00±5.42d	5.07±0.09c	65.48±21.53b
Sweet potato starch	332.88±40.13bc	162.04±0.06i	170.84±40.18a	228.08±3.89f	66.04±3.83ef	4.34±0.19e	57.40±9.69b
Cassava starch	271.88±1.94d	221.08±3.18f	50.80±5.13f	354.38±4.42c	133.30±1.24b	5.00±0.10c	77.85±0.64a
Mean	330.46	231.65	94.74	337.86	109.72	5.09	76.72
p level	***	***	***	***	***	***	**

SPS-Sweet potato starch; MSF-Moringa seed flour; ***p<0.001; **p<0.01

Means with the same letters in the same column are not significantly different (p>0.05)