RHEOLOGICAL AND SENSORY PROPERTY OF MILLET-SESAME AND MORINGA BLEND PORRIDGES

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Abstract: The rheological and sensory properties of porridges reconstituted from instant cereal mixes (ICM) of blends of 0.75% citric acid soaked dehulled millet, dehulled sesame and moringa leaf powder (MLP) was studied. The ratio of 0.75% citric acid soaked dehulled millet to dehulled sesame to MLP was varied at 9 levels; 100: 0: 0, 95: 5: 0, 90: 10: 0, 85: 15: 0, 80: 20: 0, 90: 5: 5, 85: 10: 5, 80: 15: 5 and 75: 20: 5% (w/w). The millet-sesame and moringa blend porridges designated as samples A, B, C, D, E, F, G, H and I, respectively. Each ICM blend was slurried, screened (710 µm) and drum dried using a double drum dryer.ICM were reconstituted at 10% w/v with cold water and evaluated for texture profile, flow behavior, dynamic oscillation and sensory properties. The texture profile of porridges from ICM significantly differed ($p < 0.05$) for hardness (0.496 to 1.408 g), adhesiveness (-0.047 to -0.063 gs) and springiness (3.740 to 4.451). The millet-sesame and moringa blend porridges showed pseudoplastic flow behavior. The viscoelastic behavior characterized by storage modulus (G') and loss modulus (G") showed that samples A-E had behavior typical of a solid-like material while samples F-I, had behavior typical of liquid-like material. Samples A-Ehad taste (7.16 to 7.93) and overall acceptability (7.23 to 8.03) mean scores that compared favorably with the taste (7.80) and overall acceptability (7.70) scores of commercial products. Porridges from millet-sesame blends depict a true gel while the porridges from blends of millet, sesame and MLP of weak gels.
Keywords: Breakfast cereals, instant cereal mixes, millet, moringa leaf powder

Introduction

Breakfast cereals evolve from conventional technology such as cooking of grains, milling of grains into flour or slurries to contemporary technology such as drum drying or extrusion to produce ready to eat (RTE) breakfast cereals (Patel *et al*., 2012). Traditional methods of porridge making involve cooking of milled food grains either in milk or water to a soft semisolid consistency (Goyat *et al*., 2019). However, the reconstitution of RTE breakfast cereals is easy and confers high water absorption capacity because of the pregelatinization of starch components of grains initiated by contemporary technology such as drum drying or extrusion which causes the disruption of starch granules that has tendency to absorb water on soaking (Kince *et al*., 2018). Breakfast cereals produced from conventional technology require longer cooking / preparation time compared to those produced from contemporary technology that may require either hot or cold water for reconstitution before consumption (Fast, 1990).Breakfast cereals are mostly consumed in the forms of either thick or thin porridges and the difference is concentration of the flour used for preparation (Moussa *et al*., 2011). Stiff (thick) maize porridge is made by adding ca. 30% w/v maize flour to boiling water while thin maize porridge is prepared by adding ca. 10% w/v maize flour in a similar manner (Onyango, 2014). Thick porridges are 'solid' like and can be eaten with hand, while thin porridges are 'fluid' like or 'semi-fluid' intended for drinking in a glass or cup (Murty and Kumar, 1995; Moussa *et al*., 2011). Porridge is a continuous matrix of starch molecules hence viscosity is considered an important indicator of quality. Therefore, the manipulation and breakdown of food inside the mouth up to the stage of swallowing plays a key and important role in sensory perception, consumer acceptability and food intake (Yadav *et al*., 2014; Makame *et al*., 2019).

Rheological properties of foods describe the deformation, flow or rupture of foods under applied stress. These rheological properties can be assessed using either instrumental or sensory methods. Instrumental methods involve a number of parameters such as texture, viscosity, viscoelasticity, pasting, etc whereas sensory parameters are based on visual and tactile perception prior to consumption (Tumwebaz e*et al*., 2015). Yadav *et al*. (2014) studied the rheological quality of pearl millet porridge as affected by grit size. High quality instant sorghum porridge flours for West African Market using continuous processor cooking was also studied by Moussa *et al* (2011). Onyango (2014) studied the physical properties of dry-milled maize meals and their relationship with the texture of stiff and thin porridges. The stiff maize meal porridge had a peak and total shearing force that ranged from 42.25 to 80.93N and 409.87 to 838.99Ns^{-1}, respectively while thin maize meal porridges had firmness and consistency values that ranged from 0.24 to 1.28N and 5.58 to 34.04Ns^{-1}, respectively (Onyango, 2014). However, there is dearth of information on the texture, viscosity, viscoelasticity and sensory characterization of porridges reconstituted from blends of millet, sesame and MLP. Therefore, this study is aimed to evaluate the rheological and sensory properties of millet-sesame and moringa blend porridges.

Materials and Methods

Materials

Millet (*Pennisetumglaucum*) and sesame (*Sesamumindicum*) were purchased from Lafia Modern market, in Nasarawa State – Nigeria while *Moringa oleifera* leaves were harvested from College of Agriculture residential quarters, Lafia-Nigeria.

Millet grains were cleaned, conditioned for 15 min using water (30±2°C) and dehulled (using the mortar and pestle), sun dried and winnowed using raffia trays to separate bran from the dehulled grains. Furthermore, the dehulled millet grains were soaked in 0.75% citric acid to effect depigmentation which led to the whitening (L* value, 76.10) of grain (Adgidzi, 2017). Sesame was cleaned and dehulled by floatation method (NAERLS, 2011). Moringa leaf powder (MLP) was produced by method described by de Saint Sauver (2010).

Preparation of instant cereal mixes (ICM)

The ratio of 0.75% citric acid soaked dehulled millet to dehulled sesame to MLP was varied at 9 levels; 100: 0: 0, 95: 5: 0, 90: 10: 0, 85: 15: 0, 80: 20: 0, 90: 5: 5, 85: 10: 5, 80: 15: 5 and 75: 20: 5% (w/w). Each blend was made into a slurry, screened through a 710 µm sieve and drum dried at 2 Pa, 120.2°C, 2 rpm rotating speed (of drums) with feed gap of 0.2 mm using double drum dryer (R. Simon LTD, Nottingham England). Dehulled sesame was incorporated up to 20%

because of the high oil content (48.85%) while (MLP) was used at 5% based on the recommendations of Carew *et al*. (2012).

Preparation of millet-sesame moringa blend porridges

Instant cereal mixes with the ratios of 0.75% citric acid soaked dehulled millet to dehulled sesame to MLP varied at 9 levels; 100: 0: 0, 95: 5: 0, 90: 10: 0, 85: 15: 0, 80: 20: 0, 90: 5: 5, 85: 10: 5, 80: 15: 5 and 75: 20: 5 % (w/w) was reconstituted at 10% w/v with cold water in a plastic canister of 400 ml capacity and designated as samples A, B, C, D, E, F, G, H and I, respectively.

Rheology

a) **Texture profile analysis (TPA):** Texture profile analysiswas performed using texture analyzer (TA-XT2i Plus Stable Micro System, UK) with load capacity of 5 kg according to the method described by Lopimai and Moongngam (2013) with some slight modifications. Ten grammes of ICMwas reconstituted with 90 ml of water on a plastic canister of 400 ml capacity. It was compressed to 50% with a cylindrical probe $10mm$ diameter, pre-test speed $1mm/sec$, test speed $2mm/sec$, post speed $10mm/sec$ and trigger force of 1 g. Parameters derived from texture profile analysis were; hardness, springiness, cohesiveness, adhesiveness and resilience.
b) **Flow behavior:** Viscosity characteristics of millet-sesame and moringa blend porridges were determined from shear rate and shear stress data (Bhattacharya and Bhattacharya 1996; Mousa *et al*., 2011). After warming the instrument, dynamic controlled stress rheometer (Thermo HaakeRheometer RS600), 1 ml of porridge was loaded onto the parallel plates. Viscosity was determined up to shear rate range of 0.1 to 2000s-1 at 25℃ using the probe PP35Ti with gap distance of 1 mm. An inbuilt software (Rheowin) was used to generate the viscosity and shear rate values of samples on a graph.
c) **Dynamic oscillation measurements:** Dynamic oscillation measurements on millet-sesame and moringa blend porridges were performed using dynamic controlled stress rheometer (Thermo HaakeRheometer RS600) with parallel plate of 25mm geometry and distance between plates 1mm. After warming the instrument, a strain sweep test was carried out to determine the viscoelastic linear region of strain of the reconstituted samples. Frequency sweep measurement at a strain of 0.25τ was within the linear viscoelastic region. Dynamic oscillations were taken on reconstituted samples loaded on the plate at a constant strain of 0.25τ in a frequency range of 0.1 to 100Hz at 25℃. An inbuilt software (Rheowin) was used to generate the G', G" and tan δvalues of samples on a graph (Pereira *et al*., 2008).

Sensory evaluation

Sensory attributes of reconstituted instant cereal mixes (10% w/v) were assessed based on appearance, mouth feel, taste, aroma, aftertaste and overall acceptability. A 25-member trained panelist was used to carry out the assessment. The quality attributes were assessed on a 9-point hedonic scale with 9 = extremely like and 1 = extremely dislike. The ratings from the Hedonic scale were subjected to analysis of variance (ANOVA). The significance of mean differences was determined by DMRT (Duncan multiple range test) as described by Ihekoronye and Ngoddy (1985).

Statistical analysis

The experimental design was Completely Randomized Design (CRD). The data generated from the study was subjected to Analysis of Variance (ANOVA) using the statistical software IBM SPSS version 20. Means were separated using Duncan Multiple Range Test (DMRT) and significance was accepted at p<0.05.

Results and Discussion

Texture profile of reconstituted instant cereal mix (porridges)

The texture profile of porridges of instant cereal mixes from blends 0.75% citric acid soaked dehulled millet, dehulled sesame and MLP is shown in Table 1.

The hardness, adhesiveness, springiness, cohesiveness, gumminess and resilience values ranged from 0.496 to 1.408 g, -0.047 to -0.063 gs, 3.740 to 4.451, 1.293 to 2.980, 0.698 to 4.197 and 0.002 to 0.004, respectively. There were significant differences ($p < 0.05$) among samples for hardness, adhesiveness, springiness, cohesiveness, gumminess and resilience. It was observed that the hardness, adhesiveness, springiness, cohesiveness, gumminess and resilience values of porridges increased with increase in sesame inclusion of the ICM (samples B, C, D and E). Similar trend was also observed for porridges reconstituted from ICM with the blends of millet, sesame and MLP. However, the control sample (A) had lower texture profile (-0.047 to 3.740) compared to ICM with sample I having higher values (-0.063 to 4.450).

Higher values of textile profile values (-0.063 to 4.450) observed in sample I may have been influenced by higher level (20%) of dehulled sesame and MLP (5%) inclusion.

The physical modification of ICM by the drum drierwhichled to the gelatinization of starch granules may have further influenced the textural profile of samples (porridges) in this study. The starch microstructure of ICM analyzed by the scanning electron microscope was observed to be flat and broken suggesting that the starch granules were probably destroyed during the drum drying process (Adgidzi, 2017). Consequently, drum dried products are more thermally degraded and in the process gelatinized thus improving the textural characteristics of foods (Avula, 2005). A similar trend was observed for the textural properties of porridges of pre-gelatinized brown rice replaced with different levels (0, 50, 60, 70, 80, 90 and 100%) of pregelatinized banana flour, the hardness (0.43 to 0.73N), adhesiveness (0.05 to 0.21Ns^{-2}), springiness (0.74 to 0.86), cohesiveness (0.68 to 0.88) and gumminess (0.29 to 0.64) of the samples varied significantly (Loypimai and Moongngarm, 2013). Similarly, 10% w/v potato starch suspension samples were reported by Singh *et al.* (2010) with the following textural parameters; hardness (22.96- 48.41 g), adhesiveness (75.22 – 138.54 gmm), cohesiveness (0.423 – 0.547), gumminess (10.97 – 21.71) and springiness (0.896 – 1.017).

Hardness is the force required for a pre-determined deformation and cohesiveness is the energy required in mastication, biting and releasing of jaws (Trinh and Glasgow, 2012). It is also defined as the strength of internal bonds in a food. Adhesiveness is the work required to overcome the sticky forces between the sample and the probe. Gumminess is the energy the energy needed to disintegrate a semi-solid food until it is ready for swallowing. Springiness is the rate at which a deformed sample returns to its original size and shape while resilience measures how well a product fights to regain its original position. It is observed from the study that the TPA values for all samples were generally low. However, the TPA values of the control sample significantly differed ($p < 0.05$) from TPA values millet-sesame and moringa blend porridges, thus inclusion of sesame and MLP greater than 20 and 5% respectively could likely increase the TPA values of porridge thereby increasing the stiffness of the porridges when consumed. The texture profile analyzer mimics what happens in the mouth when product is consumed (Makame *et al*., 2019).

Table 1: Texture profile of reconstituted instant cereal mixes of 0.75% citric acid soaked dehulled millet, dehulled sesame and MLP

Sample code	0.75% citric acid soaked dehulled millet:dehulled sesame: MLP ratio	Hardness (g)	Adhesiveness (gs)	Springiness	Cohesiveness	Gumminess	Resilience
A	100:0:0	$0.496{\pm}0.24^{d}$	$-0.047{\pm}0.00^{a}$	$3.740{\pm}0.62^{b}$	$1.293{\pm}0.49^{d}$	$0.698{\pm}0.33^{d}$	$0.004{\pm}0.00^{d}$
B	95:5:0	$0.822{\pm}0.27^{c}$	$-0.055{\pm}0.00^{bc}$	$4.450{\pm}0.00^{a}$	$2.252{\pm}0.37^{bc}$	$1.917{\pm}0.51^{c}$	$0.003{\pm}0.00^{ab}$
C	90:10:0	$0.942{\pm}0.12^{bc}$	$-0.057{\pm}0.00^{bcd}$	$4.449{\pm}0.00^{a}$	$2.368{\pm}0.01^{bc}$	$2.231{\pm}0.16^{bc}$	$0.003{\pm}0.01^{ab}$
D	85:15:0	$1.100{\pm}0.08^{bc}$	$-0.063{\pm}0.01^{d}$	$4.449{\pm}0.00^{a}$	$2.586{\pm}0.05^{abc}$	$2.848{\pm}0.15^{b}$	$0.002{\pm}0.02^{b}$
E	80:20:0	$1.006{\pm}0.11^{bc}$	$-0.057{\pm}0.00^{bcd}$	$4.450{\pm}0.00^{a}$	$2.436{\pm}0.09^{bc}$	$2.454{\pm}0.19^{bc}$	$0.003{\pm}0.01^{ab}$
F	90:5:5	$0.972{\pm}0.21^{bc}$	$-0.052{\pm}0.00^{ab}$	$4.450{\pm}0.00^{a}$	$2.173{\pm}0.22^{c}$	$2.144{\pm}0.38^{bc}$	$0.003{\pm}0.02^{ab}$
G	85:10:5	$1.164{\pm}0.36^{ab}$	$-0.059{\pm}0.00^{cd}$	$4.451{\pm}0.00^{a}$	$2.508{\pm}0.05^{bc}$	$2.920{\pm}0.08^{b}$	$0.002{\pm}0.00^{b}$
H	80:15:5	$1.077{\pm}0.12^{bc}$	$-0.059{\pm}0.00^{cd}$	$4.450{\pm}0.00^{a}$	$2.638{\pm}0.03^{ab}$	$2.848{\pm}0.21^{b}$	$0.003{\pm}0.01^{ab}$
I	75:20:5	$1.408{\pm}0.06^{a}$	$-0.063{\pm}0.00^{d}$	$4.450{\pm}0.00^{a}$	$2.980{\pm}0.05^{a}$	$4.197{\pm}0.15^{a}$	$0.002{\pm}0.00^{b}$

Values are means of triplicate determination ± standard error mean(SEM). Means bearing the same superscript in the same column are not significantly different (p>0.05)

KEY

Sample code (Millet-Sesame and Moringa blend porridges)	0.75% citric acid soaked dehulled millet (%)	Dehulled sesame (%)	MLP (%)
A	100	0	0
B	95	5	0
C	90	10	0
D	85	15	0
E	80	20	0
F	90	5	5
G	85	10	5
H	80	15	5
I	75	20	5

Flow behaviour of instant cereal mixes (porridges)

The relationship between viscosity and shear rate of reconstituted instant cereal mixes (porridges) is shown in Figs. 1 to 9. The viscosity of porridges of the samples A, B, C, D, E, F, G, H and I ranged from 25.59 to 2737 mPas, 16.45 to 2966 mPas, 12.84 to 3193 mPas, 27.04 to 4161 mPas, 10.28 to 510 mPas, 16.12 to 1358 mPas, 6.12 to 640.2 mPas, 10.85 to 619.3 mPas and 1.65 to 507.3 mPas, respectively while the shear rate values of samples ranged from 1.07 to 1874s^{-1}, 1.05 to 1779s^{-1}, 1.06 to 1792s^{-1},1.03 to 1571s^{-1} , 1.07 to 397s^{-1}, 1.05 to 1863s^{-1}, 1.08 to 1602s^{-1} , 1.08 to 583s^{-1} , 1.09 to 1608s^{-1}, respectively.

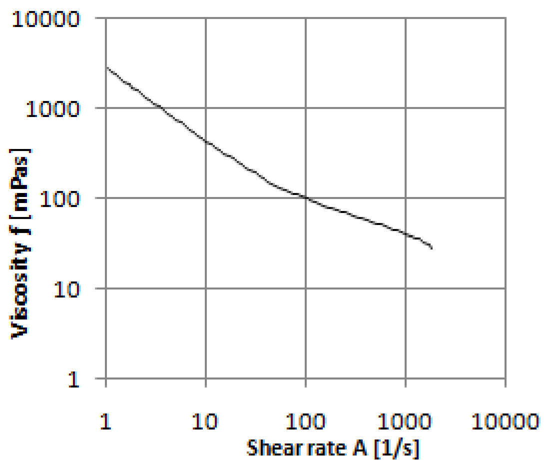

Fig. 1: Flow behavior of ICM (porridge)from 0.75% citric acid soaked dehulled millet, dehulled sesame and MLP with the ratio 100:0:0% (w/w)

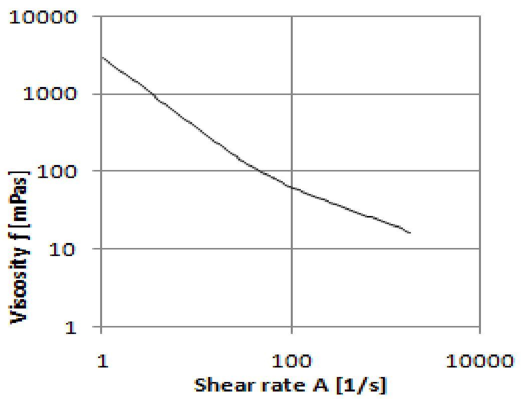

Fig. 2: Flow behavior of ICM (porridge) from 0.75% citric acid soaked dehulled millet, dehulled sesame and MLP with the ratio 95:5:0% (w/w)

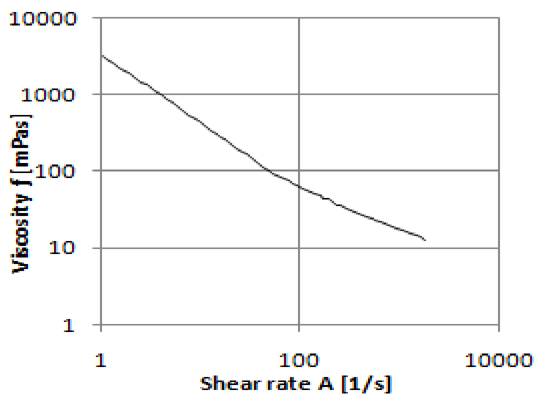

Fig. 3: Flow behavior of ICM (porridge) from 0.75% citric acid soaked dehulled millet, dehulled sesame and MLP with the ratio 90:10:0% (w/w)

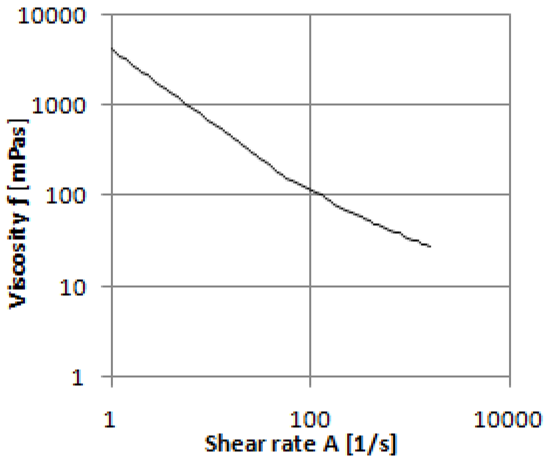

Fig. 4: Flow behavior of ICM (porridge) from 0.75% citric acid soaked dehulled millet, dehulled sesame and MLP with the ratio 85:15:0% (w/w)

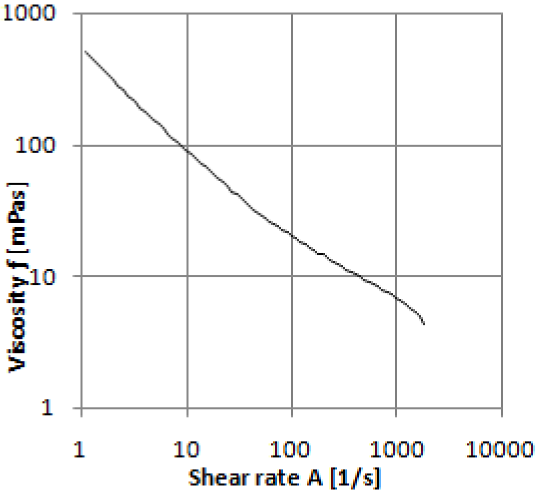

Fig. 5: Flow behavior of ICM (porridge) from 0.75% citric acid soaked dehulled millet, dehulled sesame and MLP with the ratio 80:20:0% (w/w)

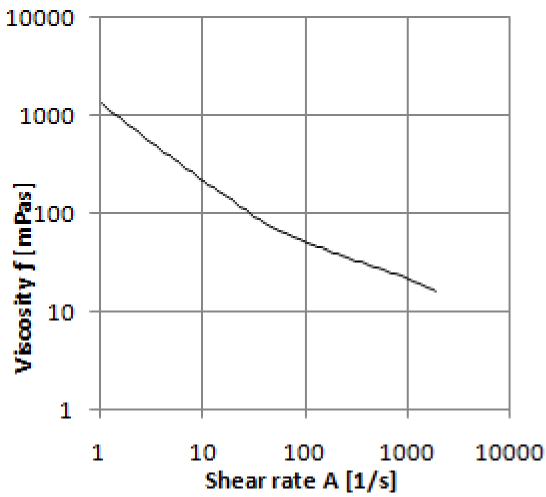

Fig. 6: Flow behavior of ICM (porridge) from 0.75% citric acid soaked dehulled millet, dehulled sesame and MLP with the ratio 90:5:5% (w/w)

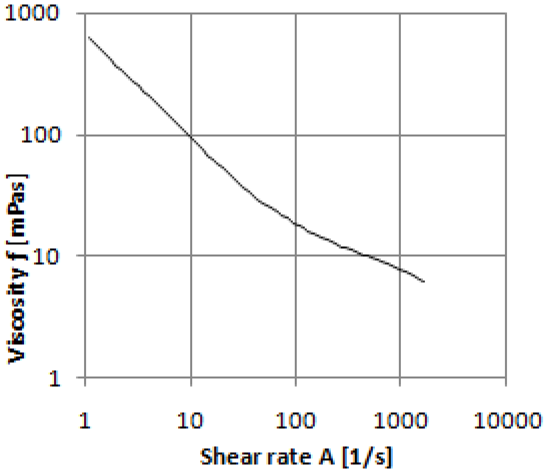

Fig. 7: Flow behavior of ICM (porridge) from 0.75% citric acid soaked dehulled millet, dehulled sesame and MLP with the ratio 85:10:5% (w/w)

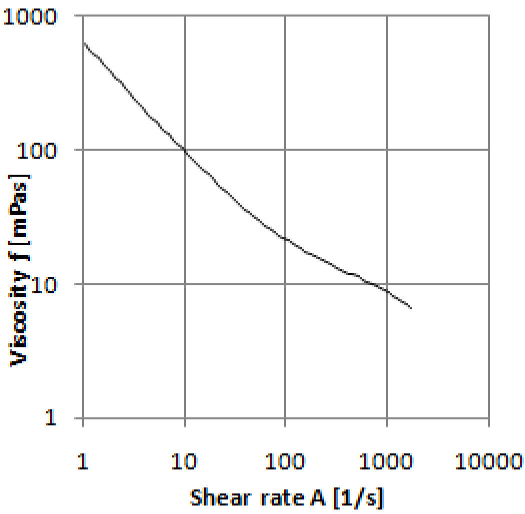

Fig. 8: Flow behavior of ICM (porridge) from 0.75% citric acid soaked dehulled millet, dehulled sesame and MLP with the ratio 80:15:5% (w/w)

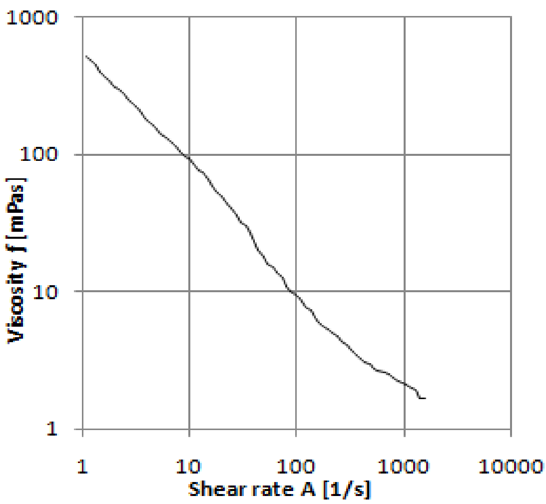

Fig. 9: Flow behavior of ICM (porridge) from 0.75% citric acid soaked dehulled millet, dehulled sesame and MLP with the ratio 75:20:5% (w/w)

The relationship between viscosity and shear rate in Figs. 1 – 9 showed that viscosity decreased (4161 to 1.65 mPas) with increase in shear rate (1.03 to 1874s^{-1}) for all the products indicating that porridges of the instant cereal mixes exhibited pseudo-plastic behavior which is also known as shear thinning behavior. This observation is in agreement with the report of Tabilo-Munizaga and Barbosa-Canovas (2005) for food gels. The flow behaviour of samples was unaffected by the levels of blending dehulled sesame and MLP with 0.75% citric acid soaked dehulled millet. Similar trend was observed for conventionally cooked porridges and instant thin porridges of sorghum (Moussa *et al.*, 2011).

Dynamic oscillation measurements of porridges

The dynamic oscillation measurements involve parameters assessed by the viscoelastic properties of foods. The viscoelastic properties of reconstituted instant cereal mix (porridges) are shown on the rheograms in Figs. 10 to 18. Porridges had the following viscoelasticity properties; sample A - E had G′ (storage modulus) ranged from 280.3 to 10470 Pa, 318.1 to 19110 Pa, 177.4 to 20490 Pa, 117.9 to 9119 Pa and 150.3 to 19470 Pa, respectively and samples F- I had G′ (storage modulus) ranged from 284.9 to 4932 Pa, 147.5 to 4894 Pa, 142.6 to 21020 Pa and 167.2 to 11930 Pa, respectively. The G″ (loss modulus) values for samples A-E ranged from 32.83 to 1372 Pa, 42.73 to 9528 Pa, 18.27 to 6284 Pa, 15.92 to 2947 Pa and 23.46 to 4181 Pa, respectively while samples F- I had G″ (loss modulus) values that ranged from 7.24 to 7239 Pa, 8.602 to 7751 Pa, 25.24 to 24920 Pa and 24.97 to 17250 Pa, respectively. The tanδ values for samples A- E ranged from 0.018 to 0.19, 0.109 to 0.499, 0.0909 to 0.718, 0.17 to 0.389 and 0.134 to 1.041, respectively whereas samples F – I had tanδ values that ranged from 0.0174 to 1.468, 0.04045 to 1.208, 0.130 to 2.058 and 0.0214 to 1.446, respectively.

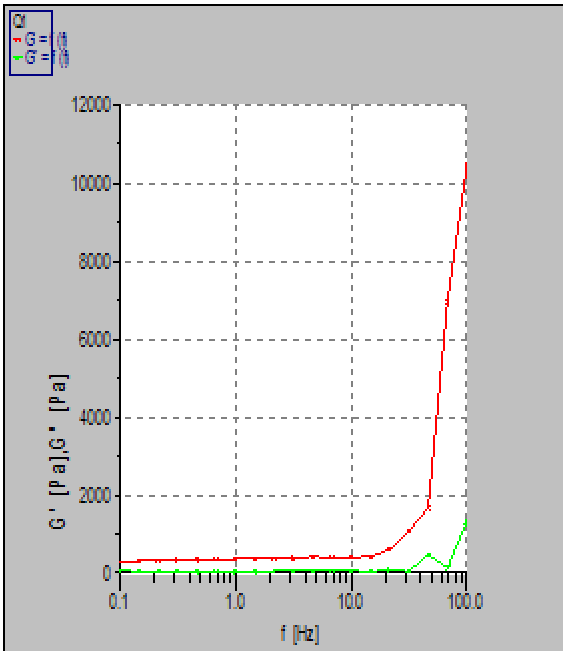

Fig. 10: Viscoelastic properties of ICM from dehulled millet soaked 0.75% citric acid, dehulled sesame and MLP with ratio 100:0:0

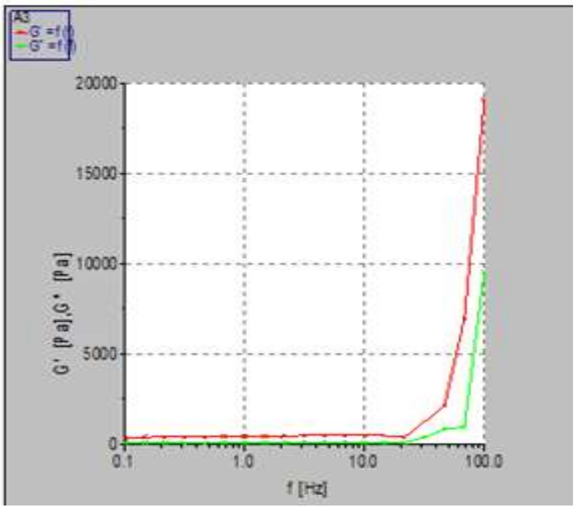

Fig. 11: Viscoelastic properties of ICM from dehulled millet soaked 0.75% citric acid, dehulled sesame and MLP with ratio 95:5:0

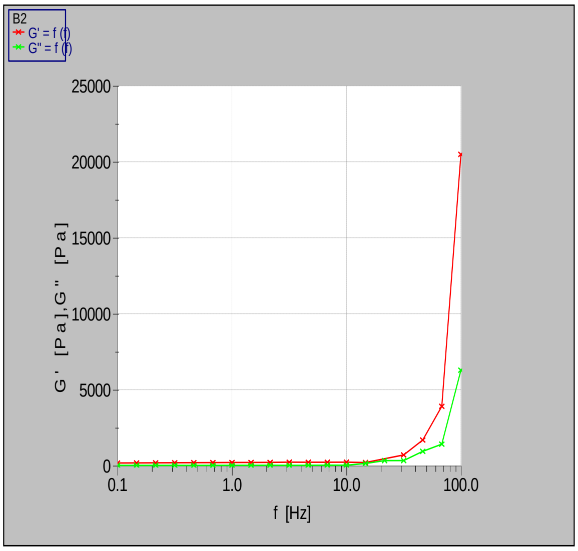

Fig. 12: Viscoelastic properties of ICM from dehulled millet soaked 0.75% citric acid, dehulled sesame and MLP with ratio 90:10:0

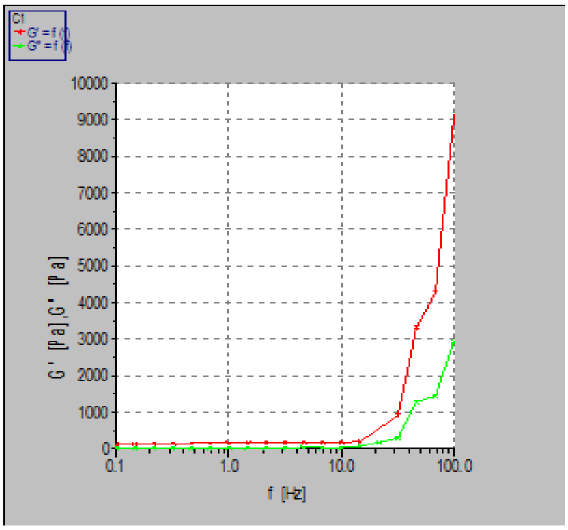

Fig. 13: Viscoelastic properties of ICM from dehulled millet soaked 0.75% citric acid, dehulled sesame and MLP with ratio 85:15:0

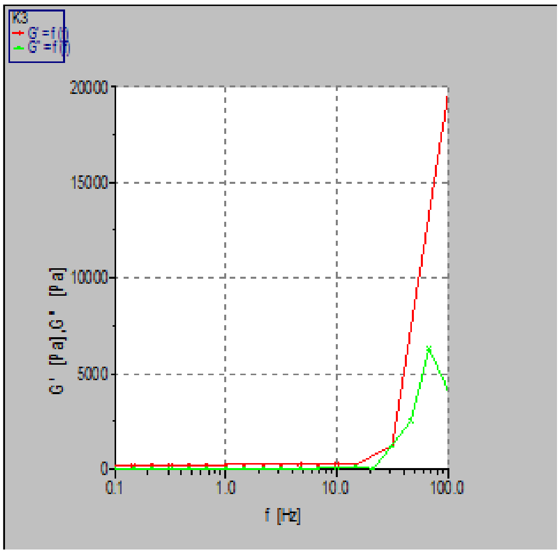

Fig. 14 Viscoelastic properties of ICM from dehulled millet soaked 0.75% citric acid, dehulled sesame and MLP with ratio 80:20:0

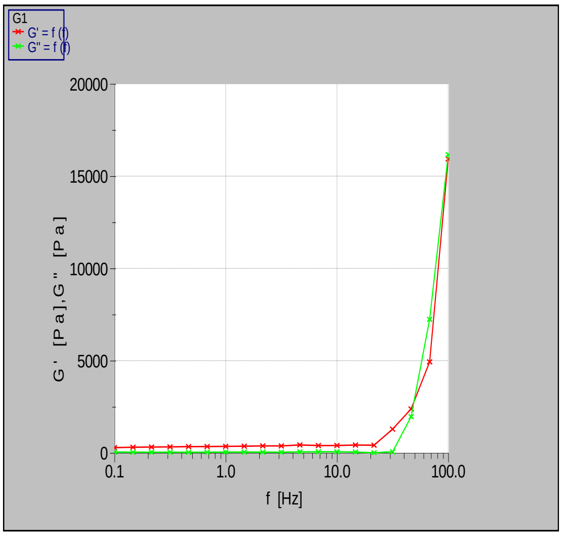

Fig. 15: Viscoelastic properties of ICM from dehulled millet soaked 0.75% citric acid, dehulled sesame and MLP with ratio 90:5:5

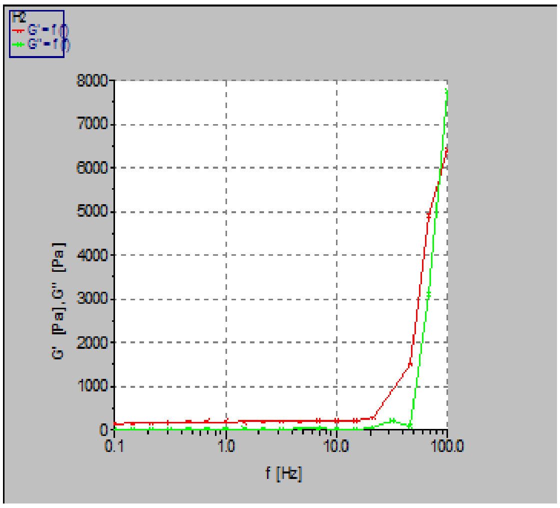

Fig. 16: Viscoelastic properties of ICM from dehulled millet soaked 0.75% citric acid, dehulled sesame and MLP with ratio 85:10:5

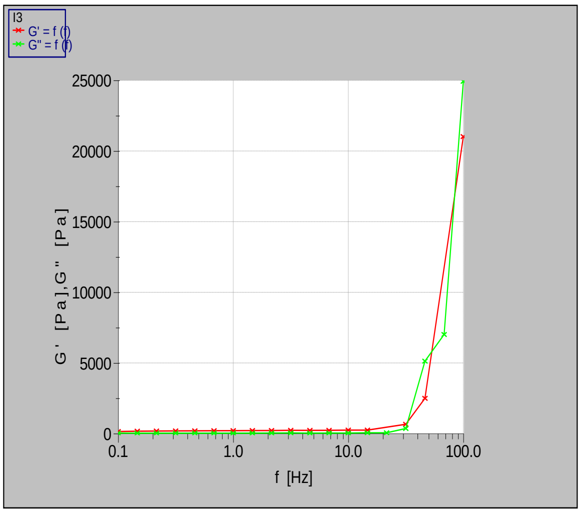

Fig. 17: Viscoelastic properties of ICM from dehulled millet soaked 0.75% citric acid, dehulled sesame and MLP with ratio 80:15:5

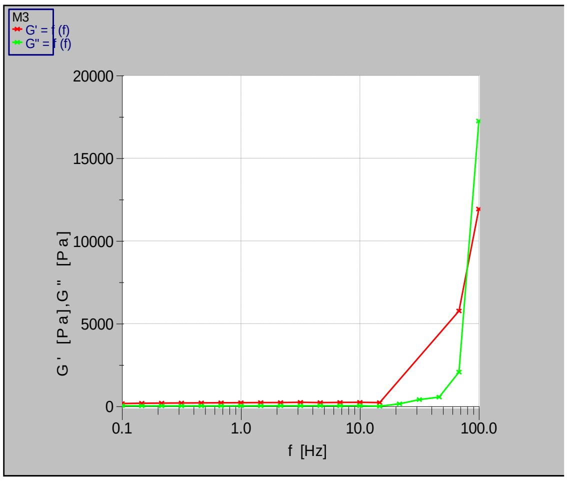

Fig. 18: Viscoelastic properties of ICM from dehulled millet soaked 0.75% citric acid, dehulled sesame and MLP with ratio 75:20:5

The viscoelastic behavior of porridges characterized by storage modulus (G´) and loss modulus (G″) showed that G´ exceeded G″ for samples A to E; thus, exhibiting a solid-like behavior that depicts deformation will be elastic and the energy recoverable while for samples F to I, G″ exceeded G´ thus exhibiting a fluid-like behavior that depicts deformation will be viscous and the energy dissipated. This is in agreement with the findings of Tabilo-Munizaga and Barbosa-Canovas (2005) who reported that if G´ exceeded G″ it implies that when stress is applied toa gel, the polymeric materials resist deformation and return to their original shape while if G″ exceeded G´ the polymeric materials are distorted and may not return to their original shape. This implies that, for porridges A-E, when stress is applied (in the form of stirring) the gel network structure of products return to their original shape because the structure is intact. However, for products F-I when stress is applied (in the form of stirring) the gel network structure cannot return to their original shape because the structure is distorted, thus the products have a tendency to become solution-like and pour. The inclusion of MLP may have influenced the distortion of the gel network structure due to its fiber content (6.72%) reported by Adgidzi, (2017).

The peak G′, G″ and tan δ values of starch from different corn types ranged from 2172 to 5354 Pa, 383 to 920 Pa and 0.122 to 0.181 respectively. It was seen that, G′ exceeded G″ for all the different corn types as observed by Sandhu *et al.* (2004). Tanδ (G″/G′) is a ratio that compares the amount of energy lostto the amount of energy stored during a cycle of deformation (Dapcevic-Hadnadev *et al*., 2005; Tabilo-Munizaga and Barbosa-Canovas, 2005). The magnitude of Tanδ (G″/G′) interprets the type of gel, if Tanδ (G″/G′) is less than 1 it is a true gel. It is considered a weak gel if Tanδ (G″/G′) value is higher than 1 and lower than 10, a strong gel if the Tanδ (G″/G′) value is greater than 10. In this study, the Tanδ (G″/G′) values of samples A to E were less than 1; thus depicting true gels while samples F to I had Tanδ (G″/G′) values that was greater 1; thus depicting weak gels. Sopade *et al.* (2004) explained that, tan δ values can be taken as an indicator of the structure organization (molecular interactions) in a material.

Sensory properties of instant cereal mixes (porridges)

The sensory properties of instant cereal mix (porridges) from graded blends of 0.75% citric acid soaked dehulled millet, dehulled sesame and moringa leaf powder are shown in Table 2. There were significant differences ($p < 0.05$) among samples in terms of mean scores for taste (6.13 to 7.93), appearance (5.83 to 8.00), aroma (5.53 to 7.87), mouth feel (6.70 to 7.83), aftertaste (5.90 to 8.60) and overall acceptability (6.17 to 8.03).

Table 2: Sensory scores of instant cereal mix (porridge) of 0.75% citric acid soaked dehulled millet, dehulled sesame and MLP

Sample code	0.75% citric acid soaked dehulled millet:dehulled sesame:MLP ratio	Taste	Appearance	Aroma	Mouth Feel	After taste	Overall Acceptability
A	100:0:0	6.77±0.15^{bcd}	7.37±0.90^{abc}	7.00±0.07^{abc}	7.63±0.25^{ab}	7.60±0.40^{b}	7.50±1.12^{ab}
B	95:5:0	7.16±0.31^{abc}	7.30±0.03^{abc}	6.87±0.34^{bcd}	7.33±0.09^{ab}	7.00±0.15^{bcd}	7.30±0.53^{ab}
C	90:10:0	7.73±0.05^{ab}	8.00±0.10^{a}	7.87±0.95^{a}	7.83±1.12^{a}	7.70±0.91^{b}	7.23±0.64^{ab}
D	85:15:0	7.93±1.07^{a}	8.00±0.47^{a}	7.47±0.15^{ab}	7.90±0.57^{a}	7.30±0.07^{bc}	7.87±0.56^{a}
E	80:20:0	7.20±1.02^{abc}	7.63±0.91^{ab}	7.50±0.21^{ab}	7.63±0.43^{ab}	7.40±0.90^{bc}	8. 03±1.78^{a}
F	90:5:5	6.45±0.97^{cd}	6.57±0.52^{cd}	6.17±0.07^{cdef}	7.33±1.34^{ab}	6.70±0.97^{cde}	6.90±1.90^{bc}
G	85:10:5	6.67±0.23^{cd}	5.83±1.05^{d}	5.90±0.66^{ef}	7.20±0.06^{bc}	6.20±0.50^{ef}	6.43±0.13^{c}
H	80:15:5	6.93±0.04^{abcd}	5.87±0.11^{d}	5.97±1.34^{def}	7.03±0.51^{bc}	6.40±0.39^{def}	6.33±0.10^{c}
I	75:20:5	6.13±0.70^{d}	6.63±0.41^{cd}	5.53±0.82^{f}	7.07±0.68^{bc}	5.90±1.01^{f}	6.17±0.16^{c}
Commercial Breakfast	Fast O Meal	7.80±0.17^{a}	7.60±0.97^{ab}	6.80±1.51^{bcde}	7.40±0.23^{ab}	6.80±0.89^{cde}	7.70±1.21^{ab}
Cereals	Kunun tsamiya	7.30±0.13^{abc}	7.00±0.20^{bc}	7.70±1.01^{ab}	6.70±0.11^{c}	8.60±0.56^{a}	7.70±1.01^{ab}

Values are means of 25 replicates ± standard deviation. Means bearing the same superscript in the same column are not significantly different ($p>0.05$)

KEY

Sample code (Millet-Sesame and Moringa blend porridges)	0.75% citric acid soaked dehulled millet (%)	Dehulled sesame (%)	MLP (%)
A	100	0	0
B	95	5	0
C	90	10	0
D	85	15	0
E	80	20	0
F	90	5	5
G	85	10	5
H	80	15	5
I	75	20	5

The mean score for taste of sample D (7.93) compared favorably with the taste score of the commercial product, Fast 'O'Meal (7.80) suggesting similarities in the synergistic effect of millet/ sesame and maize/soybeans blends. Mean score for appearance of sample E (7.63) compared favorably with the commercial product, Fast 'O' Meal (7.60). Lower mean appearance scores were observed for porridges from ICM containing dehulled millet, dehulled sesame and MLP suggesting lower preferences for samples F, G, H and I which could be associated with MLP due to the presence of chlorophyll that imparted green colour to products. The high mean score (8.60) for the aftertaste of porridge from Kunun tsamiya suggest that it was most preferred due probably to the effect of tamarind and ginger contained in the commercial product.

Porridges of mixes of samples A, B, C, D and E compared favorably with commercial products, Fast 'O' Meal and Kunun tsamiya. Porridges of ICM from graded blends of 0.75% citric acid soaked dehulled millet, dehulled sesame and MLP had lower mean scores for all the sensory attributes assessed except for mouth feel. The inclusion of moringa leaf powder to the mixes did not seem to affect the mouth feel of products, as the mean scores only varied slightly. However, the inclusion of MLP negatively affected the color and tastes of samples F, G, H and I thus, suggesting that MLP was responsible for their low preferences. This may have been influenced by the presence of chlorophyll in the leaf. Similar trend was observed by Dachana *et al.* (2010) who reported that, increase in dried moringa leaf inclusion up to 15% affected the crust and crumb of cookies by imparting green color.

Conclusion

The texture profile of reconstituted ICM (porridges) from blends of 0.75% citric acid soaked dehulled millet, dehulled sesame and MLP showed low hardness, adhesiveness and cohesiveness values which implied that porridges can be used with cup and spoon. It was apparent that the differences in the level of blends of millet, sesame and MLP were reflected in the texture profile of porridges. All porridges exhibited pseudoplastic, shear thinning characteristics. The viscoelastic properties of millet-sesame blend porridges exhibited a solid-like behavior that depicts deformation will be elastic and the energy recoverable while the millet-sesame and moringa blend porridges exhibited a fluid-like behavior that depicts deformation will be viscous and the energy dissipated. Porridges from millet-sesame blends depict a true gel while the porridges from blends of millet, sesame and MLP depict weak gels. The acceptability of the porridges from millet-sesame blends compared more favorably with commercial products than porridges from blends of millet-sesame and MLP.

Conflict of Interest

Authors declare that there is no conflict of interest reported in this work.

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