EFFECT OF GERMINATION ON THE INVITRO-DIGESTIBILITY AND PASTING PROPERTIES OF COMPLEMENTARY FOOD FROM RICE, PIGEON PEA AND CARROT FLOUR BLENDS

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Abstract
The germination of cereal grains can be very useful in improving the invitro-digestibility and pasting properties of flours in new product development and their behaviour during preparation of complementary foods. Therefore, this study examined the effect of germination on the invitro-digestibility and pasting properties of complementary food from blends of rice, pigeon pea protein concentrate and carrot flour. Rice and carrot were processed according to standard methods. Pigeon pea was germinated at 25^{O}c for 48h, dried before obtaining the pigeon pea protein concentrate flour. The resulting flours were formulated in the ratio of 60:10:30, 65:10:25 and 70:10:20 for rice, pigeon pea protein and respectively while commercial product serves as control. Protein and starch digestibility were estimated by in-vitro enzymatic digestion while pasting properties were determined using rapid visco-analyzer. The protein digestibility decreases as the concentration of the rice increases when it was digested for 1h which ranged from 75.53 to 85.665 and increased significantly when it was digested for 6h from 79.12 to 93.95. Likewise starch digestibility decreases as the concentration of the rice increases. Germinating the pigeon pea significantly increased the pasting properties. However, the blend with the lowest rice inclusion had the best in-vitro digestibility and better pasting properties.

Keywords: Complementary food, Blends, Germination, Invitro-digestibility, Pasting properties,

1.0 Introduction

Complementary foods play a dynamic role in infant growth and development because they supplement the infant's nutritional and developmental needs when breast milk alone is no longer sufficient (Temesgen, 2013). A good and sufficient complementary food should have a high nutrient density, low viscosity, bulk density, and appropriate texture, as well as a high energy, protein, and micronutrient content and a consistency that allows for easy consumption (Balasubramanian *et al.,* 2014). The recommended age for starting complementary feeding is 6 months; one reason for this is the physiologic delay in pancreatic α-amylase production and discharge in normal infants (Schiess *et al.,* 2010). Traditional complementary foods, which are typically made of cereals and or root crops, may be deficient in macronutrients as well as micronutrients such as protein, vitamin A, zinc, and iron. Furthermore, these cereal and root crop based complementary foods have high concentrations of fiber and anti-nutrients, which reduce the bioavailability of existing nutrients and are lower in nutrient density due to starch gelatinization, which immediately fills the stomach of infants. To address these issues, various traditional food processing techniques are being used to create complementary food from locally available low-cost food items that are nutritious and acceptable.

Germination is a natural process that occurs during the growth period of seeds in which they meet the minimum growth and development requirements (Sagronis *et al.,* 2006). During this time, reserve materials, which are commonly used for respiration and synthesis of new cells prior to embryo development, are degraded (Vidal-valverde *et al.,* 2002). The process begins with the quiescent dry seed absorbing water and ends with the emergence of the embryonic axis, which is usually the radicle (Adebayo and Arinola, 2017). Several studies on the effect of germination on legumes reveal that it can increase protein content, dietary fiber, reduce tannin and phytic content, and increase mineral bio availability (Ghavidel and Prakash, 2006). Germination has also been linked to an increase in vitamin concentration and trace element and mineral bioavailability (Adebayo and Arinola, 2017). Germination improved calcium, copper, manganese, zinc, riboflavin, niacin, and ascorbic acid content, according to Kaushik *et al.* (2010). Hence the aim of this study was thus to determine the effect of germination on the invitro-digestibility and pasting properties of complementary food from blends of rice, pigeon pea protein concentrate and carrot flour.

2.0 Materials and Methods

2.1 Materials

Local rice, pigeon pea, carrots and commercial product were procured from Kure Ultra-Modern Market, Minna, Niger State.

2.2 Sample preparation

After cleaning, the dried rice was milled. The method described by Marvin (2009) was used in the preparation of carrot powder. Pigeon pea seeds were sorted, cleaned and was then soaked in clean water for 6h the water was changed every 2h intervals to avoid fermentation. After soaking, the grains were spread on jute bags and left to sprout for 48h with sprinkling of water at intervals. The germinated pigeon pea was dried using solar drier for 48h and then milled. The protein extraction was carried out using the method described by Chandi and Sogi (2007).

3.0 Results and Discussion

3.1 Protein and Starch Digestibility of the Blends

The protein digestibility of the blend (Table 1) decreases as rice concentration increases when digested for1h, ranging from 75.53 to 85.665, and increases significantly when digested for6h, ranging from 79.12 to 93.95. The starch digestibility of the blend decreases as the rice concentration increases, ranging from 70.05 to 80.25. The slow digestion characteristics are determined by the arrangements of starch components (amylose and amylopectin) in concentric rings with crystalline and amorphous areas, as well as their branching patterns. When amylolytic enzymes are applied to starch granules, the enzymes migrate through the channels within the starch granules, resulting in slower digestion due to inside out and side by side digestion (Zhang and Hamaker, 2009). Enzymatic digestion usually begins at the surface pores and interior channels; this side by side digestion gradually enlarges the channel by digesting both crystalline and amorphous regions at the same time (Miao *et al.,* 2015).

3.2 Pasting properties of the blends

The peak viscosity (PV) of the blends (Table 2) ranged from 134.465 to 177.355 RVU. Peak viscosity varies in relation to swelling power and disruption rate of starch granules (Rithesh *et al.,* 2018). A higher peak viscosity indicates a greater capacity for water binding and swelling power. During the cooking process, the control had the lowest break-down value (Thiranusornkij *et al.,* 2018). All of the formulated blends had higher peak viscosities than the control blend. Low peak viscosity of a diet implies that the complementary diet will form a low viscous paste rather than a thick gel on cooking and cooling (Otegbayo *et al*., 2006). This means that the gruel will be a high caloric density per food unit volume rather than a dietary bulk (Arisa *et al.,* 2013). The trough measures the ability of the paste to withstand breakthrough during heating (Adebowale *et al*., 2008). It is the minimum viscosity value in the cooking temperature phase of the RVA profile and ranged from 125.965 RVU to 165.355 RVU with the formulated blends having higher values which are significantly different from each other. The breakdown which is the difference between the peak viscosity and trough viscosity was also observed to have higher values in the formulated blends than the control with their values ranging from 9.11 RVU and 12.76 RVU. Breakdown values of the samples exhibit significant difference ($p<0.05$). The breakdown viscosity value is an index of stability of starch (Fernandez and Berry, 1989). Breakdown viscosity decreases with increasing amylose content (Lin *et al*., 2010). The higher the breakdown the lower the ability of the starch to withstand heat and shear stress during cooking (Adebowale *et al*., 2005). This infers that the formulated blends are more stable to heat and mechanical shear (Oladele and Aina, 2007) compared to the sample D (control).

The final viscosity was observed to also have higher values which varied from 170.695RVU and 185.36 RVU and are significantly different ($P<0.05$) from each other. The setback values are all significantly different ($p<0.05$) from each other and the values are higher for all the formulated blends compared to the sample D (control) with values ranging from 20.35RVU and 45.335 RVU. The peak time is a measure of the cooking time. The result shows that the value of the peak time ranged from 6.45 minutes to 8.55 minutes and they all exhibited significant difference ($p<0.05$) from each other. The pasting temperature flour blends varied between 65.75^{o}C to 73.75^{o}C and they are significantly different ($p<0.05$) from each other. The pasting temperature is an indication of the minimum temperature required to cook the sample (Kim *et al*., 1995).The attainment of the pasting temperature is essential in ensuring swelling, gelatinization and subsequent gel formation during processing. The pasting temperature is the temperature at which the viscosity starts to rise (Liang and King, 2003). From the result, the pasting temperature of the formulated blends and the control were of closed range (65.75^{0} C to 73.75^{0} C) which indicates that all he blends have low gelatinization temperatures and hence a shorter cooking time.

Table 1. Protein and Starch digestibility of the formulated blends

	Protein Digestibility		
Samples	**Digestibility at 1h (%)**	**Digestibility at 6h (%)**	**Starch Digestibility (%)**
A	$85.67^{a}\pm0.01$	$93.95^{a}\pm0.01$	$80.25^{a}\pm0.01$
B	$80.16^{b}\pm0.01$	$86.45^{b}\pm0.01$	$78.37^{b}\pm0.01$
C	$75.43^{c}\pm0.01$	$79.125^{c}\pm0.01$	$76.83^{c}\pm0.01$
D	$70.53^{d}\pm0.02$	$76.215^{d}\pm0.01$	$70.05^{d}\pm0.00$

Values are means ± standard deviation of triplicate determination. Values in the same column with different superscripts are significantly different ($p\leq0.05$).

Keys: Sample A: 60% of Rice, 10% of pigeon pea and 30% of Carrot flour
Sample B: 65% of Rice, 10% of Pigeon pea and 25% of Carrot flour
Sample C: 70% of Rice, 10% of Pigeon pea and 20% of Carrot flour
Sample D: Control (Commercial Product)

Table 2. Pasting properties of the blends

Samples	Peak Viscosity (RVU)	Final viscosity (RVU)	Setback (RVU)	Breakdown (RVU)	Pasting time (Min)	Pasting Temperature (° C)	Trough (RVU)
A	$177.36^{a}\pm0.00$	$185.36^{c}\pm0.01$	$20.35^{d}\pm0.00$	$12.76^{a}\pm0.01$	$8.55^{a}\pm0.00$	$65.75^{d}\pm0.00$	$165.355^{a}\pm0.01$
B	$171.23^{b}\pm0.01$	$188.11^{b}\pm0.01$	$28.76^{c}\pm0.04$	$11.63^{b}\pm0.01$	$8.00^{b}\pm0.00$	$68.16^{c}\pm0.01$	$160.230^{b}\pm0.01$
C	$168.00^{c}\pm0.01$	$199.04^{c}\pm0.00$	$40.16^{b}\pm0.01$	$10.76^{c}\pm0.01$	$7.62^{c}\pm0.00$	$69.15^{b}\pm0.00$	$158.155^{c}\pm0.00$
D	$134.46^{d}\pm0.01$	$170.69^{d}\pm0.02$	$45.34^{a}\pm0.01$	$9.11^{d}\pm0.01$	$6.45^{d}\pm0.00$	$73.75^{a}\pm0.00$	$125.960^{d}\pm0.01$

Values are means ± standard deviation of triplicate determinations. Values in the same column with different superscripts are significantly different ($p \leq 0.05$).

Keys: Sample A: 60% of Rice, 10% of pigeon pea and 30% of Carrot flour
Sample B: 65% of Rice, 10% of Pigeon pea and 25% of Carrot flour
Sample C: 70% of Rice, 10% of Pigeon pea and 20% of Carrot flour
Sample D: Control (Commercial Product)

4.0 Conclusion

There was a positive effect of germination on the formulated complementary food because tests on its digestibility revealed that it can be easily digested. It also demonstrated excellent pasting qualities.

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