

Research Application Summary

Proximate composition and selected functional properties of complementary foods from teff fortified with soybean and orange-fleshed sweetpotato

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Abstract

The proximate composition and selected functional properties of teff-based extruded and traditional complementary foods (CFs) were evaluated. For extrusion, teff, soybean and orange-fleshed sweet potato (OFSP) were separately processed into their respective flours and mixed in a percentage ratio of 70:20:10, respectively. The mixture was then extruded into a complementary food (ComF1). For traditional methods, portions of teff grains separately germinated for 24 and 48 h were dried and ground. Similarly, small portions of soybean grains were separately blanched, roasted and then each ground to fine flour. Four traditional CFs (ComF2, ComF3, ComF4, ComF5) were developed by blending flours of ungerminated teff, germinated teff, blanched or roasted soybean and OFSP using the same ratios (70:20:10). The blending resulted in a higher protein (12.94 g/100 g) and fat (8.68 g/100 g) contents. Extrusion significantly ($p < 0.05$) increased the protein content (17.92 g/100 g) but decreased the fat (6.22 g/100 g) whereas the traditional methods did not affect them. Energy content of the CFs ranged from 391.63 to 400.60 kCal/100 g. All CFs met the requirements of protein and energy for 6-8 months old infants. The bulk density and water absorption index of the CFs were significantly lower. The highest water solubility index was found for ComF1 (16.63%), and the *in vitro* protein digestibility of ComF1 was significantly ($p < 0.05$) high (87.62%). The study revealed the potential of developing weaning products from teff, soybean and orange-fleshed sweet potato that are both nutritionally and functionally desirable despite a few anomalies.

Key words: Blanching, complementary food, extrusion cooking, germination, soybean, Teff

Résumé

La composition chimique et quelques propriétés fonctionnelles sélectionnées des aliments complémentaires (ACs) extrudés à base de teff et traditionnels ont été évaluées. Pour l'extrusion, le teff, le soja et patate douce à chair orange (PDCO) ont été broyés séparément en leurs farines respectives puis mélangées dans un rapport de pourcentage de 70:20:10, respectivement. Le mélange a été ensuite extrudé en un aliment complémentaire (ComF1). Pour les méthodes traditionnelles, des portions des grains de teff germés séparément pour 24 et 48 h ont été séchées et broyées. De même, de petites portions de grains de soja ont été séparément blanchies ou grillées et ensuite broyées en farine fine. Quatre ACs traditionnels (ComF2, ComF3, ComF4, ComF5) ont été développés en mélangeant les farines de teff non germé, teff germé, le soja blanchi ou grillé, et PDCO en utilisant les mêmes ratios (70:20:10). Le mélange a abouti à des teneurs protéiniques (12,94g/100 g) et lipidiques (8,68g/100 g) plus élevées. L'extrusion a significativement ($p < 0,05$) augmenté la teneur en protéines (17,92g/100 g), mais a réduit la teneur lipidique (6,22g/100 g), alors que les méthodes traditionnelles ne les ont pas affectées. La teneur énergétique des ACs variait de 391,63 à 400,60 kCal/100 g. Tous les ACs remplissaient les exigences de protéines et d'énergie pour les 6-8 mois nourrissons. La masse volumique apparente et l'indice d'absorption de l'eau des ACs étaient significativement plus faibles. L'indice de solubilité dans l'eau le plus élevé a été observé pour ComF1 (16,63%) et la digestibilité des protéines *in vitro* pour ComF1 était significativement ($p < 0,05$) élevé (87,62%). L'étude a révélé le potentiel de développement des produits de sevrage à base de teff, le soja et la patate douce à chair orange qui sont souhaitables à la fois sur le plan nutritionnel et fonctionnellement malgré quelques anomalies.

Mots clés: Blanchir, aliments complémentaires, la cuisson-extrusion, la germination, le soja, le teff

Background

Protein-energy malnutrition (PEM), the silent emergency (Anuonye *et al.*, 2010), coupled with other problems such as lack of proper hygiene, improper food preparation and storage practices, infectious diseases and dietary taboos, have continued to ravage mankind, especially in the Sub-Saharan Africa, the world's most food-insecure region (Makeri *et al.*, 2011). The problem is even worth among infants and children. According to a recent report (WHO *et al.*, 2015), globally 50 million infants were wasted in 2014. The PEM in infancy begins when the child is introduced to additional foods known as complementary foods. Infants are usually introduced to such transitional foods around the age of six month. According to the FAO/WHO category, those from 6-8 months old (WHO/UNICEF, 1998) are very susceptible as they are being introduced to the new foods while at the same time their biological systems did not grow fully to digest and utilize the foods they receive. Therefore, especial attention is required to improve the nutritional and functional properties of the complementary foods to be fed to this group of infants.

Owing to economic and to some extent traditional beliefs, the majority of the poor communities in developing countries cannot afford commercially processed and fortified complementary foods or animal origin foods to feed their infants. They usually depend on the locally-available crops (usually cereals) that are not supplemented with legumes and/ or tubers. These foods often lack the required level of macro-and micro-nutrients. Cereals are a good source of the essential amino acids, methionine and cysteine, as well as B-complex vitamins but limiting in lysine. On the other hand, most legumes are rich in lysine but low in sulfur-containing amino acids. Compositing of cereals and legumes results in a good complementarity of a number of nutrients (Mensa-Wilmot *et al.*, 2003). Moreover, such foods are usually of high bulk and not of the desirable (easy-to-swallow) semi-liquid consistency (Nout, 1993). The use of locally available crops for processing complementary foods for low-income communities through the application of traditional approaches has been promoted for decades (Elias, 1974; Molina *et al.*, 1983; Castell-Perez, 1998). However, these foods need proper formulation and processing so as to improve their nutritional values and functional properties.

Complementary foods were formulated and processed from a mixture of teff, soybean and orange-fleshed sweet potato (OFSP) through low-cost extrusion cooking and traditional methods (soaking, germination [teff], blanching or roasting and dehulling [soybean], peeling, blanching and drying [OFSP]). The aim of the study was, therefore, to develop complementary foods that are protein- and energy-dense with improved functional properties (bulk density, water absorption and water solubility indices and also of better protein digestibility).

Description of the study

Red teff [*Eragrostis tef* (Zucc.) Trotter], soybean [*Glycine max* (L.) Merr.] and orange-fleshed sweet potato (OFSP) [*Ipomoea batatas* (L.) Lam], all from Ethiopia, were utilized as raw materials. The teff grains were purchased from *Dangila* town, (farmer's local market), one of the areas where there is surplus production of teff in the North-Western part of Ethiopia. Soybean, locally called *Belessa-95*, was collected from Pawe Agricultural Research Centre (*Pawe* town, Western Ethiopia) and OFSP (*Tulla* variety) from Awassa Agricultural Research Centre (*Hawassa* town, Southern Ethiopia).

Two different approaches were applied to prepare complementary foods: Extrusion cooking and traditional methods. In extrusion cooking, all the raw materials were separately processed into their respective flours and then formulated into a composite flour in a percentage proportion of 70:20:10, respectively. The flour samples were packaged in polyethylene bags, sealed and kept in plastic buckets at room temperature until extrusion process was carried out. The formulated flour was extruded using a pilot-scale twin-screw extruder. The following extrusion operating conditions were used to process the raw flour mixture into a pre-cooked complementary food (ComF1): Moisture content (22%), barrel temperature (120 °C) and screw speed (225 rpm) based on preliminary tests. The feed rate was maintained constant at 64 g/min. The extrudates were ground using a laboratory-scale mill (Type ZM 100, F. Kurt Retsch GmbH & Co.KG, Germany) fitted with a 0.5 mm sieve. It was then kept in a cold room (10 °C) until analysis.

Meanwhile, in the traditional methods, a small portion of teff grains were germinated following the method described by Badau *et al.* (2006). The germination was conducted at room temperature (25 ± 2 °C) for two durations, 24 hr and 48 hr. and subsequently dried and milled into fine flour. Soybean grains were processed using two approaches: blanching and roasting. Blanching was conducted according to the method described by Iombor *et al.* (2009) whereas roasting was carried out following the WFP procedure (WFP, 2004). Both the blanched and roasted grains were then dehulled using a lab-scale decorticator. The hulls were manually removed and the grains were milled to fine flour. OFSP was processed the same way as done for extrusion cooking: peeling, slicing, drying and ground into fine flour. The flour samples (germinated teff, blanched soybean, roasted soybean, OFSP) together with flour from ungerminated teff were formulated into complementary foods using the same proportion (70:20:10) for teff, soybean and OFSP, respectively, as done for extrusion cooking. However, in this case, 10% of the germinated teff was used thus reducing the raw (unprocessed teff) to 60%. Four complementary foods (ComF2, ComF3, ComF4 and ComF5) were developed using this approach.

Determination of proximate composition. Proximate composition of the raw flour materials, composite flour and those of blended and extruded complementary foods were analyzed according to AOAC International standard methods (AOAC International, 2000). Available carbohydrate was determined by difference while energy was calculated using the Atwater's conversion factors: 4 kcal/g for crude protein, 9 kcal/g for crude fat and 4 kcal/g for available carbohydrate (FAO, 2003).

Determination of functional properties. Bulk density was determined by adding a 25 g sample in a 50 ml measuring cylinder (Iwe and Ngoddy, 1998). Water absorption index and water solubility index were determined according to the method developed for cereals (Anderson, 1982). The in vitro protein digestibility was determined following the modified pepsin method described by (Mertz *et al.*, 1984).

Statistical analysis. One-way analysis of variance (ANOVA) was applied to the data by the use of IBM SPSS for Windows (Version 21). The significant difference was analyzed by Tukey's HSD (honest significant difference) test. The level of significance was set at 5% probability level.

Results and discussion

The results for proximate composition of the raw and traditionally processed materials used for formulating the complementary foods are shown in Table 1. The moisture and ash contents were in the range of 2.51 to 7.36 and 2.12 to 5.03 g/100 g, respectively. Ash content indicates the level of minerals, and also it may be a quality parameter for contamination in a given food sample (Kavitha and Parimalavalli, 2014). It was affected by the processes employed. Germination, both for 24 and 48 hr, significantly decreased the ash content of teff. This decrease might be due to leaching of minerals during washing and soaking of the grains (Inyang and Zakari, 2008). However, ash content of soybean significantly increased during blanching (Ugwuona *et al.*, 2012) and roasting (Kavitha and Parimalavalli, 2014) which

could be due to volatilization of the organic matter. As expected, significantly high crude protein ($p < 0.05$) was found for the raw soybean (34.57 g/100 g), very close to that reported by Anuonye *et al.* (2010). The blanched and roasted soybean also gave slightly higher protein contents of 35.59 and 36.22 g/100 g, respectively. The lowest value of protein was that of OFSP (5.70 g/100 g) which is nearly similar to what was reported by Omodamiro *et al.* (2013) for some sweet potato varieties. A similar trend was also observed for crude fat. The highest crude fat (22.99 g/100 g) was found in raw soybean which agrees with the available literature (Anuonye *et al.*, 2010) while the lowest was recorded for OFSP (0.84 g/100 g). Germination of teff, both for 24 and 48 hr, significantly decreased the crude fat contents. Similar results were found by Megat Rusydi *et al.* (2011) for some legumes and rice varieties. The decrease in fat content might be due to the increased activities of the lipolytic enzymes which hydrolyze fats to fatty acids and glycerol during germination (Kavitha and Parimalavalli, 2014). The fatty acids are further oxidized to carbon dioxide and water to generate energy for the germination process (Hahm *et al.*, 2009). Blanching and roasting had also significantly ($p < 0.05$) reduced the fat contents of soybean which could be due to loss of some fat during the heating process, especially, the reduction caused by roasting that was drastic (Table 1).

Crude fiber contents ranged from 3.76 for OFSP to 5.76 g/100 g for roasted soybean. There was significant increase during germination of teff, whereas only slightly during blanching and roasting of soybean. The OFSP gave the highest value of carbohydrate (86.09 g/100 g), which is in good agreement with a previous report (Oke and Workneh, 2013), followed by 48 h and 24 h germinated teff, 82.05 and 79.78 kcal/100 g, respectively.

The proximate composition of the composite flour, that is, the mixture of the flours from the three raw materials, and that of the final complementary foods processed using extrusion cooking and traditional approaches (germination [teff], blanching and roasting [soybean]) are presented in Table 2. No significant difference ($p > 0.05$) was found in the moisture and crude fiber contents of the complementary foods and the composite flour as well, but they are lying within the range prescribed for complementary foods. The extruded complementary food (ComF1) had the lowest ash content (3.20 g/100 g) compared to those of the composite flour and the traditional complementary foods (ComF2 to ComF5). This could probably be because of loss of some minerals as a result of the high temperature and shearing effect. The highest ash content is obtained for ComF3 (3.55 g/100 g) and ComF5 (3.56 g/100 g) which could be due to the substantial destruction of phytate (result not shown here) during blanching of soybean grains that would otherwise bind the minerals through formation of inorganic complexes.

The presence of soybean in the formulations considerably increased the protein (12.34 g/100 g) and fat (8.68 g/100 g) contents in the composite flour. Similar results were reported by Anuonye *et al.* (2010) for a mixture of acha and soybean. Extrusion cooking significantly increased ($p < 0.05$) the protein content to 17.92 g/100 g. Obatolu *et al.* (2000) reported that such an increase in protein content could be because of denaturation of protein molecules as a result of the high extrusion temperature and that this makes the protein molecules more susceptible to proteolysis and therefore improves protein utilization. However, the extrusion process reduced the fat content to 5.82 g/100 g, which could be because of the loss of fat

Table 1. Proximate composition of flour samples (dry weight basis) from raw and processed grains

Flour sample		Proximate composition (g/100g)					
		Moisture	Ash	Crude protein	Crude fat	Crude fiber	Available CHO
Teff	Raw/Ungerminated	6.35 ± 0.12 ^d	3.28 ± 0.03 ^{bc}	7.80 ± 0.05 ^{ab}	5.71 ± 0.84 ^c	3.87 ± 0.27 ^a	79.34 ± 0.85 ^c
	Germinated-24 h	4.87 ± 0.69 ^c	2.12 ± 0.25 ^a	10.40 ± 0.76 ^b	2.72 ± 0.28 ^{ab}	4.98 ± 0.49 ^b	79.78 ± 0.65 ^c
	Germinated-48 h	4.53 ± 0.05 ^c	2.24 ± 0.19 ^a	8.01 ± 0.37 ^{ab}	2.50 ± 0.13 ^a	5.19 ± 0.06 ^b	82.05 ± 0.07 ^c
Soybean	Raw	3.16 ± 0.32 ^{ab}	3.08 ± 0.02 ^b	34.57 ± 0.83 ^c	22.99 ± 1.11 ^c	5.34 ± 0.70 ^b	34.02 ± 1.81 ^a
	Blanched	3.48 ± 0.19 ^b	3.61 ± 0.09 ^c	35.59 ± 2.04 ^c	10.22 ± 1.05 ^d	5.35 ± 0.29 ^b	45.22 ± 2.76 ^b
	Roasted	2.51 ± 0.43 ^a	5.03 ± 0.11 ^d	36.22 ± 0.76 ^c	4.57 ± 0.31 ^{bc}	5.76 ± 0.33 ^b	48.43 ± 1.00 ^b
OFSP	Processed	7.36 ± 0.03 ^c	3.61 ± 0.04 ^c	5.70 ± 0.31 ^a	0.84 ± 0.04 ^a	3.76 ± 0.17 ^a	86.09 ± 0.18 ^c

Values are mean ± standard deviation of three independent determinations and different superscripts in the same column with different letters are significantly ($p < 0.05$) different. CHO – Carbohydrate

Table 2. Proximate composition of the developed complementary foods (dry weight basis)

Complementary food	Proximate Composition (g/100 g) and Energy (kCal/100 g)						
	Moisture	Ash	Crude protein	Crude fat	Crude fiber	Available CHO	Energy
Composite flour	5.82 ± 0.14 ^a	3.28 ± 0.03 ^b	12.94 ± 0.15 ^a	8.68 ± 0.37 ^c	4.15 ± 0.31 ^a	70.95 ± 0.59 ^b	413.68 ± 2.12 ^d
ComF1	6.53 ± 0.93 ^a	3.20 ± 0.03 ^a	17.92 ± 0.41 ^b	6.22 ± 0.59 ^b	4.43 ± 0.34 ^a	68.23 ± 0.81 ^a	400.60 ± 3.49 ^c
ComF2	5.77 ± 0.05 ^a	3.27 ± 0.01 ^b	13.41 ± 0.49 ^a	5.83 ± 0.47 ^{ab}	4.27 ± 0.11 ^a	73.23 ± 0.35 ^c	398.99 ± 2.23 ^{bc}
ComF3	5.58 ± 0.17 ^a	3.55 ± 0.02 ^c	13.53 ± 0.09 ^a	4.69 ± 0.53 ^a	4.35 ± 0.07 ^a	73.87 ± 0.59 ^c	391.88 ± 2.51 ^{ab}
ComF4	5.70 ± 0.04 ^a	3.27 ± 0.01 ^b	13.17 ± 0.43 ^a	5.80 ± 0.51 ^{ab}	4.29 ± 0.14 ^a	73.46 ± 0.32 ^c	398.74 ± 2.55 ^{abc}
ComF5	5.50 ± 0.01 ^a	3.56 ± 0.01 ^c	13.30 ± 0.16 ^a	4.68 ± 0.57 ^{ab}	4.37 ± 0.08 ^a	74.10 ± 0.66 ^c	391.63 ± 2.82 ^a
Recommended value	10 ^μ	4.1 ^μ	9.1 [‡]	6 ^μ	5 [‡]	45 [‡]	202 [‡]

ComF— Complementary Food. Values are mean ± standard deviation of three independent determinations and different superscripts in the same column with different letters are significantly ($p < 0.05$) different. [‡](WHO/UNICEF 1998); [‡](Dewey 2005); ^μ(WFP 2014)

during the process, as some drops of fat were visible on the extruder machine. There was no significant difference ($p > 0.05$) in the protein content among the traditional complementary foods, the values ranging from 13.30 to 13.53 g/100 g. All traditionally prepared CFs can meet the recommended protein content for the targeted group of infants.

The crude fat contents of all complementary foods were significantly lower ($p < 0.05$) than that of the composite flour, but within the range prescribed for complementary foods (< 6 g/100 g) as described in the WFP technical specifications for the manufacture of Super Cereal-Corn Soya Blend (WFP, 2014). It can be seen that the fat contents of all complementary foods are safer both from nutrition and shelf stability point of view. The reduction in the fat content of ComF1 could be due to the loss of fat during the extrusion process, whereas in the case of ComF2 to ComF5, it could be due to the reduced fat levels in germinated teff, blanched soybean and roasted soybean. When the fat content of a weaning food is higher, it can impart more energy to the infant. In the event that it exceeds the desirable level, it will be disadvantageous for stability of the product as the unsaturated fatty acids are vulnerable to oxidative rancidity (Lohia and Udipi, 2015) that would shorten its shelf life.

The carbohydrate contents of the complementary foods are in the range of 68.23 g/100 g for ComF1 to 74.10 g/100 g for ComF5. The energy content of the composite flour was significantly higher (413.65 kCal/100 g) than that of all complementary foods. This could be due to the higher fat content as a result of the soybean added in the mixture. The energy content of the complementary foods ranged from 391.63 to 400.60 kcal/100 g, nearly double of the recommended value by Dewey (2005). The relatively lower energy contents of the complementary foods compared to that of the composite flour could be attributed to loss of oil during extrusion cooking of the mixture arising from high pressure and temperature (Mensa-Wilmot *et al.*, 2003). It could also be a result of loss during blanching and roasting of soybean grains as observed in the results in Table 1.

Functional properties (bulk density [BD], water absorption index [WAI], water solubility index [WSI]) and in vitro protein digestibility [IVPD]) of the composite flour and developed complementary foods results are presented in Table 3. The BD is a function of the closeness

Table 3. Selected functional properties of the developed complementary foods

Complementary food	Bulk density (g/cm ³)	Water absorption index (g/g)	Water solubility index (%)	<i>In vitro</i> protein digestibility (%)
Composite flour	0.80 ± 0.01 ^b	2.39 ± 0.02 ^a	12.22 ± 0.17 ^d	71.73 ± 2.19 ^b
ComF1	0.76 ± 0.00 ^a	4.85 ± 0.05 ^b	16.63 ± 0.98 ^e	87.62 ± 2.88 ^d
ComF2	0.74 ± 0.02 ^a	2.42 ± 0.18 ^a	8.38 ± 0.23 ^a	39.77 ± 5.85 ^a
ComF3	0.74 ± 0.01 ^a	2.20 ± 0.15 ^a	10.60 ± 0.17 ^{bc}	72.44 ± 1.76 ^b
ComF4	0.72 ± 0.01 ^a	2.47 ± 0.10 ^a	9.42 ± 0.05 ^{ab}	82.75 ± 0.38 ^{cd}
ComF5	0.74 ± 0.01 ^a	2.39 ± 0.04 ^a	11.16 ± 0.20 ^{cd}	75.01 ± 0.53 ^{bc}

Values are mean ± SD of three independent determinations and different superscripts in the same column with different letters are significantly ($p < 0.05$) different

of packaging of particles (Iwe and Ngoddy, 1998). The BDs of the complementary foods are significantly lower ($p < 0.05$) than that of the composite flour and are in the range of 0.72 to 0.76 g/cm³ with no significant difference among them. This could be an indication that both extrusion cooking and the traditional approaches (germination, blanching, roasting) have a reducing effect on BD of the complementary foods because of starch hydrolysis to simple sugars such as maltose and dextrin that absorb less water when cooked (Malleshi *et al.*, 1996; Lohia and Udipi, 2015). According to earlier reports, a lower BD is desirable in complementary feeding as it corresponds to a higher nutrient content in a lower volume of the food and thus advantageous in making infant gruels (Kulkarni *et al.*, 1991; Iwe and Ngoddy, 1998; Imtiaz, 2011; Kinyuru, 2012). On the other hand, high BD is a disadvantage for complementary foods because it can limit the nutrient intake per feed (Lohia and Udipi, 2015).

The WAI of a food product measures the water holding capacity by the starch after swelling in excess water, which corresponds to the weight of the gel formed, and thus is an index of the degree of starch gelatinization. It depends on the availability of hydrophilic groups which bind water molecules and on the gel-forming capacity of macromolecules (Ding *et al.*, 2006; Hazarika *et al.*, 2013). The highest WAI (4.85 g/g) was recorded for ComF1, which is in agreement with previous reports (Narbutaite *et al.*, 2008; Pathania *et al.*, 2013). All the traditional complementary foods, including the composite flour, showed lower WAI values ranging from 2.20 to 2.47 g/g; that is, their water absorption capacities are lower. According to previous reports (Ikujenlola, 2008; Kulkarni *et al.*, 1991; Lohia and Udipi, 2015), lower WAI is desirable for making thinner gruels or porridges in which more flour can be added per unit volume of the gruel. On the other hand, it also results in increasing the energy- and nutrient-density of the infant foods, a very important aspect in infant feeding.

The WSI is often used as an indicator of degradation of molecular components (or starch degradation or dextrinization) and measures the amount of soluble components released from the starch after extrusion (Ding *et al.*, 2006; Kokiæ *et al.*, 2013). A lower WSI is an indication of a minor degradation of starch molecules and such condition leads to less number of soluble molecules in the food (Narbutaite *et al.*, 2008). In this study, the WSI of the developed complementary foods varied significantly ($p < 0.05$) ranging from 8.38% for ComF2 to 16.63% for ComF1. The highest WSI value of ComF1 is due to the extrusion process that has degraded the starch to a greater extent, as reported in other studies (Narbutaite *et al.*, 2008; Pathania *et al.*, 2013) on extrusion cooking of cereal-based complementary foods. In this study, lower values of WSI were obtained for ComF2 (8.38%) and ComF4 (9.42%) which were produced from 24 h or 48 h germinated teff, blanched soybean and OFSP. Compared to those of ComF3 (10.60%) and ComF5 (11.16%), the lower WSI values for ComF2 and ComF4 could indicate that blanching of soybean might be responsible for lower degradation of starch than roasting.

The in vitro protein digestibility (IVPD) varied significantly ($p < 0.05$) from 39.77% (ComF2) to 87.62% (ComF1). The extruded complementary food (ComF1) showed the highest IVPD which could be because of the denaturation process as a result of the thermal treatment. This finding is in agreement with previous works (Duodu *et al.*, 2003; Lopes *et al.*, 2012;

Unit and Nadu, 2012). These authors reported that extrusion improves protein digestibility via denaturation which exposes enzyme access sites and also leads to inactivation of trypsin inhibitors. It can also be due to the reduction of phytates in the extruded CF (results not shown here) as it was found out in a previous research (Laminu *et al.*, 2011). Although the IVPDs of ComF4 and ComF5 are significantly lower ($p < 0.05$) than that of ComF1, they are still very high compared to those of ComF2 and ComF3. This might be because of the longer germination time of the teff grains (48 h) for ComF4 and ComF5. This is consistent with earlier observations that germination improves protein digestibility (Bau *et al.*, 1997; Echendu *et al.*, 2009).

Conclusion

Complementary foods prepared from a mixture of teff, soybean and orange-fleshed sweet potato, either through extrusion cooking or a combination of traditional approaches (soaking, germination, blanching, roasting, dehulling) can meet recommended level of protein, energy and other nutrients to a six-month old infant. The complementary foods have also shown desirable level of functionality with respect to bulk density, water absorption, water solubility and protein digestibility.

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