ISSN 2250-3153

Formulation and Sensory Evaluation of Yoghurt-based Weaning Foods Manufactured from Mung bean, Soybean and Brown Rice

M.A.D.D. Munasinghe*, K.F.S.T. Silva*, D.M.D.Rasika*, M.P.K. Jayarathne, K.H. Sarananda*****

* Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya, 20400, Sri Lanka
** MILCO (Pvt) Ltd, Narahenpita, Colombo, Sri Lanka
***Food Research Unit, PO. Box 53, HORDI, Department of Agriculture, Gannoruwa, Peradeniya, Sri Lanka

Abstract- Three yoghurt-based weaning foods (WF1, WF2 and WF3) designed for 1-3 years old toddlers which prepared by blending of mung beans (*Vigna radiata*), soybean (*Glycine max*) and brown rice (*Oryza sativa*), were evaluated for their chemical, physical, microbial and organoleptic properties. Proximate compositions of the yoghurt-based weaning foods were varied significantly ($P<0.05$) and fulfilled the nutritional requirements given by the Protein Advisory Group Recommendations. Water binding capacity and water solubility index were varied significantly ($P<0.05$). Total plate counts obtained separately for yoghurt, extruded grain flour mixtures and freshly prepared yoghurt-based weaning foods were within the recommendations. According to the sensory evaluation data, WF1 scored higher on average by the panelists than WF2 and WF3 in terms of appearance, aroma, mouth feel and color. However, WF2 was scored highly on average by the panelists in terms of taste and overall acceptability. Therefore, results suggests that yoghurt-based weaning foods are a potential tool for eliminating the protein-energy malnutrition among the children in developing countries which provide sufficient energy with good quality proteins in adequate levels through an cost effective way than conventional liquid-based staple cereal flour mixtures.
.

Index Terms- formulated weaning foods, mung bean, soybean, toddler, yoghurt

I. Introduction

Malnutrition has become one of the major health problems facing by the developing countries which contributes to infant mortality, poor physical and intellectual development of children which lowers the resistance to diseases [1]. Throughout the developing world, malnutrition affects about 800 million people which approximately accounts for 20 percent of the world population [2,3]. For instance, Sri Lanka Demographic and Health Survey (2006/07) highlighted that 18% of Sri Lankan children are stunt, 15% are wasted, 22% are underweighted and 4% are severely underweighted [4]. High price of commercially available weaning foods, vegetables, animal proteins and the non-availability of low priced nutritious foods, combined with bad feeding practices and late introduction of supplementary foods, are mostly responsible for the observed malnourishment among children in Asia [5]. Weaning is the process of complete transition from breast feeding to a semi solid diet. Weaning foods are generally introduced between the ages of six months to three years where the breast feeding itself no longer meets the increasing nutritional requirements of the child [6]. Therefore, there is a high possibility of occurring Protein Energy Malnutrition (PEM) during this transitional phase when children are weaned from liquid to semi-solid or fully adult foods where the growing body of children needs a nutritionally balanced and calorie dense supplementary foods such as weaning foods in addition to mother`s milk [1,3]. This can be more severe if abrupt weaning is practiced where the family menu is directly introduced to the infant that leads to malnutrition, growth retardation and higher rates of mortality [5].

In developing countries, most of the complementary foods are based on local staple foods mainly produced from cereals and given in liquid gruel form for infants [6, 7, 8]. To be suitable for the feeding of young children, these cereal-based weaning foods are prepared in liquid form by dilution with a large quantity of water, thereby resulting in more volume but with a low energy and low nutrient dense food [7]. These cereal-based gruel forms are poor in nutritional value as they are lack in essential amino acids such as threonine, lysine and tryptophan [6]. Moreover, the poor quality of protein and high viscosity of such gruel makes it difficult for the child to consume enough to meet both energy and protein requirements which leads to occurrence of protein-energy malnutrition [6, 8]. Food based approaches used in combination with nutritional education programs can be used as a strategy to overcome the nutrient deficiencies. One such strategy is blending of legumes with cereals or in other words, fortification of legumes into solely cereal-based diets. Therefore, locally available legumes: mung bean (*Vigna radiata*) and soybean (*Glycine max*) can be used due to their high protein and iron content. As these grain legumes are relatively low cost source of iron and protein, they can be used to prepare supplementary foods for children in low income families [6, 9]. Legumes are high in lysine but lack in sulfur-containing amino acids. On the other hand, cereals are lack in lysine but high in sulfur-containing amino acids [10]. Soybean is often used to improve the protein quality of cereal blends, due to its high levels of protein (40%) and fat (20%) content [8]. Moreover, soybean is rich in lysine which deficient in most cereals however, lack in sulfur containing amino acids as common in legumes. Therefore, fortification of legumes with cereals may overcome the nutritional deficiencies while improving the nutritional quality of the cereal-based weaning foods. Processing methods such as malting and extrusion has been reported to improve nutritional value of the food blends. Extrusion cooking is a food processing technology that rapidly mixes and cooks the material at temperatures of over 100 ºC and dry the product in a relatively short time [11]. This thermal process improves the nutritional quality by the inactivation of antinutritonal factors associated in legumes such as protease inhibitors, hemagglutinnins and polyphenolic compounds while eliminating vegetative microorganisms [12, 13]. On the other hand, malting converts cereal starch into fermentable sugars and improves availability of amino acids [8]. More nutritional benefits are expectable when extruded-legume fortified-cereal blends are incorporated with yoghurt. As it is a source of animal proteins rich in essential amino acids and proteins with high biological value, it may eliminates any nutrient deficiency associated with extruded grain mixtures in addition to its health benefits. For example, as the milk proteins, fat, and lactose components undergo partial hydrolysis during fermentation, yoghurt is an easily digested product of milk for infants which overcome the problems associated with lactose intolerance [14]. In addition, yoghurt based weaning food enables more nutrients in less amount comparatively to the general liquid gruel form. Therefore, the objective of the current study was to formulate an energy dense yoghurt-based weaning food rich in nutrition for 1-3 years old toddlers by blending of mung beans, soybeans with brown rice using low cost extrusion cooking.

II. MATERIALS AND METHODS

Raw Materials

Brown rice (*Oryza sativa*), mung beans (*Vigna radiata*), soybean (*Glycine max*), cocoa powder and full cream milk powder were purchased from the local market. Bovine milk for yoghurt preparation was procured from Mawela Farm, Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka.

Preparation of Raw Materials

Mung beans were washed, soaked (8 h), dried (at 50 ºC for 24 h) and roasted under an open flame (160 ºC) until become golden brown, and partially milled using a Ferrell-Ross® roller mill (Ferrell-Ross Corp, Oklanoma city, Okla, USA). Brown rice were washed, dried in a dehydrator (55 ºC for 1 h) and partially milled using a Ferrell-Ross® roller mill (Ferrell-Ross Corp, Oklanoma city, Okla, USA). Soybean grains were soaked (8 h), drained by placing on a nylon sieve (1 h), dried at 50 ºC for 24 h and roasted under an open flame (160 ºC) until become golden brown coloured. Then de-hulled using a Bauer 148-2 de-huller (Bauer bros.co, USA) and partially milled using a Ferrell-Ross® roller mill (Ferrell-Ross Corp, Oklanoma city, Okla, USA).

Formulation of Weaning Foods

Three composite weaning foods (WF1, WF2 and WF3) were formulated using varying amounts of raw materials and yoghurt (Table 1) by considering nutrient and caloric values of each ingredient in order to meet the nutrient requirement of toddlers according to the recommendations given by the World Health Organization in which 100 g portion of each weaning food enables to provide ⅓ of the daily energy and carbohydrate requirement, ⅔ of the daily protein requirement and ¼ of the daily fat requirement of a growing toddler. Each grain mixture corresponding to each weaning food was extruded separately and mixed with corresponding amount of yoghurt at serving (Table 1).

Table 1: Composition of different composite weaning foods

Ingredient	WF1	WF2	WF3
Brown rice	2	2	2
Mung beans	11	17	22
Soybeans	4	3	3
Dried milk powder	3	3	3
Yoghurt	80	75	70
Total	**100**	**100**	**100**

Extrusion Process

Prepared mung bean, soybean and brown rice were blended according to the relevant proportions as stated in the Table 1. Each blend was extruded separately using a co- rotating twin screw extruder (die size 0.25 inches) with a smooth barrel. The resulted extruded products were milled into flour using a Fitz® 832D Fitz mill (The Fitzpatrick Company, Russia) and sieved through a 0.3 mm sieve. Thereafter, 3% spray dried milk powder and 5% coco powder were mixed with each blend.

Preparation of Yoghurt

Milk was standardized with cream in order to obtain a final fat content of 4%. Homogenized and pasteurized (95 ºC for 5 min) standardized milk was inoculated with a commercial starter culture containing *Streptococcus thermophilus* and *Lactobacillus delbrueckii subsp. bulgaricus* at a rate of 2% (w/v) after addition of sugar and gelatin. The mix was incubated in an ACP incubator (ACP Co Ltd, Japan) at 42 ± 2 ºC and was terminated at pH 4.6 and stored under refrigerated conditions (4 ± 1 ºC).

Chemical Analysis

Each grain mixture was mixed with corresponding amount of yoghurt as presented in the Table 1 and proximate composition of each weaning food in gruel form was determined according to the AOAC protocols (1995) [15]. Carbohydrate content was determined by the difference between total dry matter and the sum of other proximate components (crude protein, crude fat, crude fiber, ash) while gross energy content was measured by the summation of caloric value of each nutrient using energy conversion factors given by Bangoura and Zhou (2007) [13].

Physical Properties Determination

The water binding capacity and water solubility index were determined according to the methods previously described by Griffith-L, Castell-Perez and Griffith-M. (1998) [16].

Analysis of Shelf-life

pH of the yoghurt stored under refrigerated storage (4 ± 1 ºC) was determined at 4 days intervals for 28 d using Hannah 211electric pH meter (HANNA, TOA Electronics, Ltd, Tokyo, Japan). Titratable acidity of the yoghurt was measured by titrating 9 mL of sample with 0.1 N NaOH solution using phenolphthalein as indicator, at 4 d intervals during 28 d of storage.

Microbial Analysis

The microbial analysis (Total plate count and Coliform count) was conducted separately for yoghurt and composite grain flour mixtures on the day of manufacturing, and for freshly prepared gruel form after blending of each grain mix with corresponding amount of yoghurt. Total Plate Count (TPC) was detected in each of the composite grain flour mixtures and freshly prepared yoghurt based weaning foods immediately after preparation. A series of dilutions (10^{-1} to 10^{-6}) were prepared by dissolving 1 g of each sample with 9 mL of distilled water. Then 0.1 mL of each diluent was plated out on plate count agar and incubated at 37 ºC for 48 h in a Fisher 322 incubator (Scientific Company, USA). The colonies were counted manually and the results were expressed as the number of Colony Forming Units (CFU) per gram. Coliform counts in yoghurt, composite grain flour mixtures and freshly prepared yoghurt based weaning foods immediately after preparation were detected using pour plate technique. Point one milliliters (0.1 mL) of each 10^{-1} dilution series of the corresponding sample was plated out in Violet Red Bile (VRB) agar and incubated at 30 ºC for 24 h. Colonies were identified as enumerate blue and red colonies associated with entrapped gas regardless of size or intensity of color according to the method described by Ahima (2009) and expressed as CFU/g[17].

Sensory Evaluation

Each extruded grain mix was blended with the corresponding amounts of yoghurt and the sensory evaluation of yoghurt-based weaning foods in gruel form was conducted by 30 untrained panelists drew randomly from the Faculty of Agriculture, University of Peradeniya, Sri Lanka. Each panelist received 3 samples of freshly prepared weaning foods to taste, evaluate and comment on sensory characteristics. They were asked to evaluate the appearance, aroma, taste, mouth feel, colour and overall acceptability based on a 7 point hedonic scale; like extremely =7, like very much = 6, like slightly =5, neither like nor dislike = 4, dislike slightly = 3, dislike very much = 2, and dislike extremely = 1.

Statistical Analysis

The experiment was conducted as Complete Randomized Design (CRD). One-way ANOVA (Analysis of variance) was performed to analyze data on physical and chemical analysis and means were separated by Least Significant Difference (LSD) procedure using SAS statistical software version 9.1 (SAS institute. Cary, NC, USA). Sensory data were analyzed by Friedman`s Test using SPSS statistical software version 17 (SPSS Inc., Chicago, IL, USA). All values were reported as mean ± standard error mean (SEM) and significances were determined at $P < 0.05$. All determinations were conducted in triplicates (n=3).

III. RESULTS AND DISCUSSION

Nutritional composition of the weaning foods

The nutritional composition of each weaning food resulted from the proximate analysis was presented in the Table 2. Dry matter (DM) content of the yoghurt based formulated weaning foods were varied significantly (*P*<0.05) where DM content of WF3 was greater than that of the WF1 and WF2. Results revealed that percentage of DM increased as the proportion of grain flour mixture increased. Moisture content of the three yoghurt-based weaning foods were varied significantly (*P*<0.05). As expected, the WF1 which contained the highest proportion of yoghurt in its formulation (80%) exhibited the highest moisture content. Moreover, the moisture content tended to decrease as the proportion of yoghurt decreased in the formulation.

Table 2: Nutritional Composition of different weaning foods in dry weight basis (WF1, WF2, and WF3)

Nutrient (%)	WF1	WF2	WF3
Dry matter	42.53 ± 0.04^{b}	42.53 ± 0.04^{b}	50.18 ± 0.05^{a}
Moisture	56.42 ± 1.00^{a}	53.53 ± 1.16^{b}	50.75 ± 0.35^{c}
Crude protein	15.22 ± 0.32^{b}	16.28 ± 0.37^{a}	16.19 ± 0.28^{a}
Crude fiber	0.71 ± 0.19^{c}	0.93 ± 0.10^{a}	0.81 ± 0.12^{b}
Crude fat	12.43 ± 0.37^{a}	12.38 ± 0.31^{a}	12.38 ± 0.31^{a}
Carbohydrates	69.07 ± 0.20^{a}	68.55 ± 0.30^{b}	68.10 ± 0.35^{b}
Ash	1.70 ± 0.05^{a}	1.69 ± 0.12^{a}	1.66 ± 0.30^{a}
Gross Energy (kcal)	1854.36 ± 1.20^{a}	1845.08 ± 0.41^{ab}	1835.99 ± 0.61^{b}

Note: Values in the same raw with different superscripts are significantly different at (*P*<0.05)

The percentage of crude protein (CP) among the formulated weaning foods was varied significantly where the CP content of WF2 and WF3 was greater (*P*<0.05) than that of the WF1. This may be due to the higher portion of mung bean in WF2 and WF3. Wikramanayake (1996) has stated that the processing techniques used to prepare the weaning foods such as roasting assist in breakdown of lipocytes to release fat and protein [10]. Moreover, according to Griffit et al. (1998) roasting improved sensory qualities and aided in inactivation of destructive enzymes, which improves the storage and nutritional quality of the product and reduce trypsin inhibitor activity when seed temperatures reached 90–100 °C where the lipoxygenase activity loss at temperatures of 75–80 °C [16]. Thus, it can be reasonably argued that the proteins originated from the roasted mung beans and soybeans which used to prepare weaning foods are in better quality. Moreover, according to the Codex Alimentarius Commission Recommendations (1982), a minimum protein content of 15% in food is required for maximum complementation of amino acids for a satisfactory growth of a toddler and therefore all of the yoghurt-based weaning foods tested were agreed to so-called recommendation [18]. On the other hand, a combination of plant proteins and animal proteins may fulfill the requirements of amino acids especially, essential amino acids comparatively to a solely vegetable source. In the current study, all of the evaluated yogurt-based weaning foods were consisted of both plant protein sources (soya, brown rice and mung beans) and an animal protein source (yoghurt). Therefore, it can be suggested that both quality and biological value of protein in the evaluated weaning foods are much higher than a solely cereal based weaning food. Crude fat content of the yoghurt based weaning foods was not varied significantly (*P*>0.05). Fat contents of the yoghurt based weaning foods evaluated were above the value of 10% recommended by the Protein Advisory Group (1972) Recommendations. Fat goes oxidative deterioration during storage and therefore, fat content of a particular food affects greatly to its shelf stability. Hence, a food sample with high fat content is more liable to spoilage than one with a lower fat content [1]. However, the high fat content in the experimental weaning foods is not a matter since the yoghurt and extruded grain mixture will be packed separately with intension to blend together when fed to a toddler in freshly prepared form. Therefore, the shelf life of these products is more likely to be depended on the shelf life of the yoghurt rather than on the fat content of the blended form. Yoghurt and soybean are the main sources of fat in the weaning foods tested. Soybean oil agrees with the recommendations given by the FAO/WHO (1998) in which vegetable oils are allowed to be incorporated in foods for infants and children, which will not only increase the energy density, but also acts as a carrier for fat soluble vitamins (K, A, D, E) while providing essential fatty acids. In addition, soybean and cereals contain unsaturated fatty acids which do not increase the cholesterol content in the blood; hence it can be recommended for children without causing any harmful effect on blood cholesterol level [10].

Ash content resulted from the proximate analysis reflects the mineral content of each weaning food. There was no significant difference (*P*>0.05) found among the yoghurt based weaning foods with relevant to ash content. However, it was within the acceptable range of <5% recommended by the Protein Advisory Group (1972). Crude fiber (CF) content among the formulated weaning foods were varied significantly ($P<0.05$) and was less than the maximum fiber content of 5% of the Protein Advisory Group Recommendations (1972) [19]. It was expected to increase the fiber content of the weaning foods as the proportion of extruded grain flour content increased. However, CF content of WF3 which contained 30% of extruded grain flour mixture was significantly lower than that of the WF2 which contained only 25% of extruded grain flour mixture. According to Ghasemzadeh and Ghavide (2011), incorporation of de-hulled legumes instead of whole legume grains, reported low fiber contents [20]. Accordingly, significantly lower CF content associated with the WF3 is most probably due to the addition of de-hulled mung beans although WF3 contained highest percentage (22%) of mung beans in composition. Carbohydrate content of the WF1 was higher ($P<0.05$) than that of the WF2 and WF3. In this study, brown rice was used as the main carbohydrate supplement which produce adequate amount of carbohydrates in order to fulfill the minimum carbohydrate requirement of 65% as recommended by the Protein Advisory Group`s recommendations (1972) for 1-3 year old toddler [19]. Gross energy/ caloric content of the evaluated yoghurt-based weaning foods were varied significantly. Gross energy/ caloric content of the WF1 found to be the highest ($P<0.05$) among the three yoghurt based weaning foods tested. However, no significant differences were found between the gross energy contents of the WF1 and WF2, and WF2 and WF3. Calories in a diet are provided by protein, fat and carbohydrates [10]. WF1 contained comparatively low CP content; therefore, the high caloric content associated with the WF1 more likely to be due to the comparatively high crude fat and carbohydrate content associated with it (Table 2). The caloric contents of protein, fat and carbohydrates were ranged 65.65 - 68.37, 113.12 – 118.51, and 257.33 – 259.64 kcal, respectively among the three yoghurt based weaning foods (data not shown). In other words, contribution of protein, fat and carbohydrates to the total caloric content of the evaluated yoghurt-based weaning foods were ranged from approximately 14-16%, 25-27% and 58-59%, respectively. Furthermore, according to the Protein Advisory Group recommendations, the contribution of fat and carbohydrates to the total caloric value should be <30% and within 50-60%, respectively. Thus, contribution of protein, fat and carbohydrates to the total caloric content of the evaluated yoghurt-based weaning foods were fulfilled the requirement of the Protein Advisory Group recommendations (1972).

Physical Property Measurements

Water binding capacity (WBC) and Water solubility index (WSI) of the formulated weaning foods are presented in the Table 3. The WBC of the three yoghurt based weaning foods were varied significantly ($P<0.05$). However, the values were lower than the values reported by Ahmadzadeh-Ghavidel and Prakash (2010) [21]. On the other hand, Griffith et al. (1998) observed low WBC associated with high fat, high protein with low carbohydrate levels of the weaning foods. In addition, Ghasemzadeh and Ghavide (2011) reported higher values for WBC as the starch content increased [20]. Therefore, the low WBC observed in the weaning foods is most probably due to the high protein and fat content with low starch content in the formulated weaning foods. WSI of the formulated weaning foods were varied significantly ($P<0.05$) and displayed a negative relationship ($r = -0.916$) with the WBC. In other words, WSI tended to increase as WBC decreases. High water solubility results a fine paste and improved mouth feel. The extruded products usually increase the water solubility as cooking increase the susceptibility of grain starch to glucoamylase hydrolysis which leads to gelatinization during processing [16].

Table 3: Water binding capacity (WBC) and Water Solubility Index (WSI) of formulated weaning foods in gruel form (WF1, Wf2, and WF 3)

Weaning Food	WBC (mL/g)	WSI (%)
WF1	3.06 ± 0.04^a	17.24 ± 0.23^c
WF2	1.67 ± 0.06^c	30.28 ± 0.06^a
WF3	2.49 ± 0.05^b	27.55 ± 0.05^b

Note: Values in the same column with different superscripts are significantly different at $P<0.05$

Microbial Analyses

The TPC and coliform counts of yoghurt, composite grain flour mixtures and yoghurt based formulated weaning foods are summarized in the Table 4.

Table 4: Total Plate Count (TPC) Data and Coliform Counts of yoghurt, grain mixtures and formulated weaning

Microbial count	Yoghurt	Grain Mixtures			Formulated weaning foods in gruel form		
		WF1	WF2	WF3	WF1	WF2	WF3
TPC (CFU/g)	ND	2.80×10^6	2.75×10^6	3.20×10^6	5.94×10^4	5.62×10^4	6.34×10^4
Coliform	0	0	0	0	0	0	0

Note: ND = Not determined; WF = weaning food

According to the USDA specifications and Sri Lanka Standard (SLS) Institute recommendations, the coliform count in yoghurt should be less than 10/g and 1 CFU/g, respectively [22, 23]. Coliform counts were not detected in yoghurt and composite flour mixtures and therefore, had fulfilled both recommendations. On the other hand, according to the recommendations given by the UK Food Protection Agency and Food Standards of Australia and New Zealand (FSANZ), the TPC and Coliform count of cereal flour mixtures should be $< 10^7$ CFU/g and < 3 CFU/g, respectively [24]. In addition, the acceptable Total Plate Count (TPC) and Coliform count for ready to eat food items should be $< 10^5$ CFU/g and < 3 CFU/g, respectively. Therefore, formulated weaning foods tested in this study were within the limits of acceptable range. Absence of coliform counts most probably due to the hygienic practices and good management practices employed throughout the manufacturing process including preparation of yoghurt, composite flour mixtures and yoghurt-based gruel forms.

Shelf life examination of yoghurt

The variation in pH of the prepared yoghurt has been illustrated in the Figure 1 which was measured at 4day intervals over 28 days of refrigerated storage (4 ± 1 ºC)**.**pH value of the yoghurt was continuously decreased throughout the storage period which was varied from 4.62 to 4.31, 4.58 to 4.29 and 4.64 to 4.28 in replicate 1, 2 and 3, respectively.

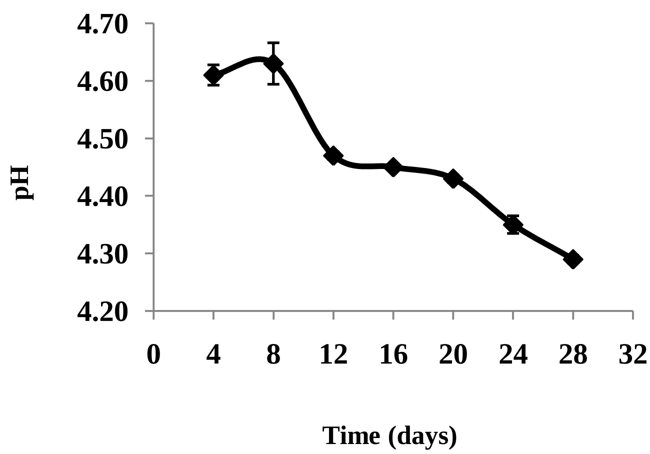

Figure 1 Variation in pH value of yoghurt during 28 days of storage under refrigerated conditions (n=3)

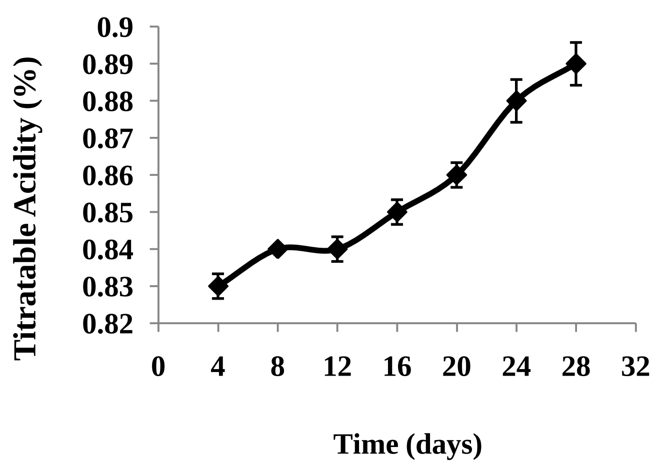

Figure 2 Variation in titratable acidity (%) of yoghurt during the 28 days of refrigerated storage (n=3)

On the 20th day, sour taste and unpleasant odor were observed in every replicate. Therefore, it was concluded that the yoghurt was unacceptable for consumption after 20 days of refrigerated storage. In addition, the average variation in titratable acidity (%) of the yoghurt which was measured at 4day intervals over 28 days under refrigerated storage has been illustrated in the Figure 2**.**Titratable acidity was continuously increased throughout the refrigerated storage period of the yoghurt which was maximized after 28 days (0.89±0.01). These values were within the recommended range of0.8- 1.25%according to the Sri Lankan Standards (1989) given for yoghurt [23]. However,most of the yoghurts available in the market have a shelf life of two weeks (14 d).Therefore**,** based on the pH and titratable acidity values, it can be suggested that the specially prepared high fat yoghurt for current study can be stored safely under refrigerated conditions for two weeks (14 d).

Sensory evaluation

The scores obtained for sensory attributes: appearance, aroma, taste, mouth feel, color and overall acceptability demonstrated no significant differences ($P>0.05$) among the 3 formulated weaning foods tested (Table 5). WF1 scored higher on average by the panelists than WF2 and WF3 in terms of appearance, aroma, mouth feel and color. WF1, WF2 and WF3 contained 80%, 75% and 70% of yoghurt, respectively (Table 1). Therefore, it can be concluded that the higher yoghurt content may have a positive influence on appearance, aroma, mouth feel and color.

Among the three formulated weaning foods, WF2 was scored highly on average by the panelists in terms of taste and overall acceptability. The average scores of WF1, WF2 and WF3 for taste was WF1 < WF3 <WF2. It is obvious that higher yoghurt content does not have positive influence on taste and something else responsible for the taste. Both WF2 and WF3 had equal amounts of brown rice and soybeans. Therefore, both brown rice and soybeans could not be responsible for the taste difference observed between WF2 and WF3. Therefore, the taste difference is more likely to be due to the difference in mung bean content in which WF2 and WF3 contained 17% and 22% of mung bean, respectively (Table 1) which was higher than that of the WF1 (11%). On the other hand, WF3 which contained highest mung bean content was ranked second on taste attribute which reflect the fact that yoghurt and mung bean content solely does not govern the taste of the weaning foods. Taste is more likely to be resulted due to a combined effect of the levels of yoghurt and mung beans where moderate levels of both yoghurt and mung bean had given the highest scores on taste attribute (WF2). Moreover, WF3 had received the lowest scores on average for all sensory attributes tested, except aroma and taste. Therefore, it is obvious that higher grain content may have a negative impact on the sensory properties, in particular appearance, mouth feel, color and overall acceptability. In addition, it can be concluded that a combined effect of the level of yoghurt and grain mixtures plays a significant role to determine the overall acceptability of the weaning food.

Table 5: Mean scores of testing panelists (n=30) for sensory properties of formulated weaning foods (WF1, WF2, and WF3) in freshly prepared gruel form

Characteristic	WF1	WF2	WF3
Appearance	5.10 ± 0.24	4.97 ± 0.25	4.80 ± 0.33
Aroma	5.03 ± 0.21	4.90 ± 0.22	4.93 ± 0.28
Taste	4.63 ± 0.27	5.03 ± 0.23	4.97 ± 0.23
Mouth feel	5.33 ± 0.19	5.20 ± 0.21	4.73 ± 0.23
Color	5.13 ± 0.22	4.93 ± 0.22	4.57 ± 0.33
Overall acceptability	4.87 ± 0.22	5.00 ± 0.20	4.63 ± 0.27

Data expressed as Mean ± SEM

Comments from the panelist were also evaluated during the sensory evaluation. Some panelists criticized the sour taste observed in some products, mainly WF1, and the clumpiness resulted due to the absent of homogenized mixing of grain mixtures and yoghurt. Complaints regarding the sourness were not observed in WF2 and WF3. Therefore, it can be concluded that the sourness associated with the WF1 could be due to the high yoghurt content (80%) which leads to the panelists to score WF1 as the lowest on taste attribute. Addition of flavor such as vanilla, strawberry and chocolate, and addition of color were among the suggestions given by the panelists in order to improve the acceptability of the weaning foods and to mask the sour taste resulted from yoghurt.

Although the overall sensory scores of formulated weaning foods remained low, it can be concluded that the WF2 is the best weaning food according to the organoleptic properties, especially due to its taste and high overall acceptability.

IV. CONCLUSION

The proximate compositions of the three extruded yoghurt-based weaning foods were varied significantly and fulfilled the requirements given by the Protein Advisory Group Recommendations (1972). Water Binding Capacity was highest (3.06±0.04) in WF1 whereas Water Solubility Index was highest (30.28±0.06) in WF2 which were significantly greater ($P<0.05$) than that of the other weaning foods. The specially prepared yoghurt was found to be safe for consumption for 2 weeks based on the titratable acidity and pH values determined during the 28 day storage period under refrigerated conditions (4±1 ºC). Total Plate Counts of the yoghurt, extruded grain flour mixtures and freshly prepared yoghurt-based weaning foods obtained separately, were within the acceptable range recommended by the Food Standards of Australia and New Zealand (FSANZ). According to the sensory evaluation data, WF1 scored higher on average by the panelists than WF2 and WF3 in terms of appearance, aroma, mouth feel and color. However, WF2 was scored highly on average by the panelists in terms of taste and overall acceptability. Based on the results, it can be suggested that fortification of legumes into the conventional cereal based weaning foods and diluting in yoghurt instead of liquid, results a product with extreme nutritional quality, cost effective and could be a possible and effective tool in order to overcome the malnutrition among children in the developing countries.

Acknowledgment

The great assistant provided by the technical staff of Food Research Unit, HORDI, and Dairy Science and Technology Laboratory, Animal Nutrition Laboratory and Food Science Laboratory of the Faculty of Agriculture, University of Peradeniya are highly acknowledged for their commitment to make this research study a success.

References

[1] Amankwah, E. A., Barimah, J., Nuamah, A. K. M., Oldham, J. H., Nnaji, C. O. & Knust, P. (2009). Formulation of weaning food from fermented maize, rice, soybean and fishmeal. *Pakistan Journal of Nutrition*, *8*(11), 1747-1752.

[2] World Health Organization. (1998). Preparation and Use of Food-based Dietary Guidelines. Report of a joint FAO. *WHO Consultation, Nicosia, Cyprus, 1995WHO, Geneva.*

[3] World Health Organization. (2000). Turning the tide of malnutrition: responding to the challenge of the 21st century. *World Health Organization*.

[4] Department of Census & Statistics. (2009). *Sri Lanka Demographic & Health Survey 2006-07*. Ministry of Healthcare & Nutrition, Colombo, Sri Lanka.

[5] Suite. (2007). Weaning Foods: Characteristics, Guidelines and the Role of Soy foods. World Initiative for Soy in Human Health: St. Louis, USA.

[6] Egounlety, M. (2002). Production of legume-fortified weaning foods. *Food research international*, *35*(2), 233-237.

[7] Sanni, A. I., Onilude, A. A., & Ibidapo, O. T. (1999). Biochemical composition of infant weaning food fabricated from fermented blends of cereal and soybean. *Food chemistry*, *65*(1), 35-39.

[8] Obatolu, V. A. (2002). Nutrient and sensory qualities of extruded malted or unmalted millet/soybean mixture. *Food chemistry*, *76*(2), 129-133.

[9] Vijayalakshmi, P., Amirthaveni, S., Devadas, R. P., Weinberger, K., Tsou, S. C. S., & Shanmugasundaram, S. (2003). *Enhanced bioavailability of iron from mungbeans and its effects on health of schoolchildren*. Shanhua (Taiwan): AVRDC.

[10] Wikramanayake, T. W. (1996). *Food and Nutrition*: Hector Kobbekaduwa Agrarian Research and Training Institute: Colombo 07, Sri Lanka.

[11] Deshpande, H. W., & Poshadri, A. (2011). Physical and sensory characteristics of extruded snacks prepared from Foxtail millet based composite flours. *International Food Research Journal*, *18*, 730-735.

[12] Mensa-Wilmot, Y., Phillips, R. D., & Hargrove, J. L. (2001). Protein quality evaluation of cowpea-based extrusion cooked cereal/legume weaning mixtures. *Nutrition Research*, *21*(6), 849-857.

[13] Bangoura, M. L., & Zhou, H. (2007). Formulation and Nutritional Quality of Extruded Weaning Food Supplemented with Whole Egg Powder. *American Journal of Food Technology*, *2*, 477-489.

[14] Tamime, A. Y., & Robinson, R. K. (1999). *Yoghurt: science and technology*. Woodhead Publishing.

[15] AOAC. (1995).*Official Methods of Analysis of AOAC International*, 16th ed: Association of Official Analytical Chemist, Maryland, USA.

[16] Griffith, L. D., Castell-Perez, M. E., & Griffith, M. E. (1998). Effects of blend and processing method on the nutritional quality of weaning foods made from select cereals and legumes. *Cereal chemistry*, *75*(1), 105-112.

[17] Ahima, J. K. (2011). *Formulation of weaning food using composite of maize groundnut and soybean and assessing its nutritional effect using animal model* (Doctoral dissertation).

[18] Codex Alimentarius Commission. (1982). Codex Standards for Foods for Special Dietary Uses Including Foods for Infants and Young Children and Related Code of Hygienic Practice. *WHO Food Standards Programme, FAO, Rome*.

[19] Graham, G. G. (1975). Protein Advisory Group's recommendations deplored. *Pediatrics*, *55*(2), 295-296.

[20] Ghasemzadeh, R., & Ghavidel, R. A. (2011). *PROCESSING AND ASSESMENT OF QUALITY CHARACTRISTIC OF CEREALS-LEGUMES COMPOSITE WEANING FOODS*. 2011 International Conference on Bioscience, Biochemistry & Bioinformatics, Singapore (Vol. 5). IACSIT Press, Singapore.

[21] Ahmadzadeh Ghavidel, R., & Prakash, J. (2010). Composite Weaning Mixes: Formulation and Quality Characteristics. *Food science and technology research*, *16*(1), 65-70.

[22] USAID. (2002).Commodities Reference Guide- Part II, Module I: Material Child Health and Nutrition: United States Agency for International Development. Retrieved Sep 22, 2011 from http://en.wikipedia.org/wiki/USAID.

[23] SLS. (1989).SLS standards for yoghurt 735:1989.Sri Lanka Standards Institute, Colombo.

[24] Australia New Zealand Food Standards Code - Standard 1.6.1 - Microbiological Limits for Food. (2011). retrieved Dec 24, 2012 from http://www.comlaw. gov.au/Details /F2011C00352.

AUTHORS

First Author – M.A.D.D. Munasinghe, M.Sc (Reading), B.Sc., Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya, 20400, Sri Lanka, mdilushi@yahoo.com

Second Author – K.F.S.T. Silva, PhD, M.Sc, B.VSc. Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya, 20400, Sri Lanka, frankserendib@gmail.com

Third Author – D.M.D. Rasika, B.Sc., Department of Animal Science, Faculty of Agriculture, University of Peradeniya, Peradeniya, 20400, Sri Lanka, dilan_rasika@yahoo.com

Forth Author–M.P.K. Jayarathne, Manager (QAR & D), Milco (Pvt.) Ltd., Narahenpita, Colombo, Sri Lanka, mgrqard@milco.lk

Fifth Author – K. H. Sarananda, PhD, M.Sc, B.Sc., Food Research Unit, PO Box 53, HORDI, Department of Agriculture, Gannoruwa, Peradeniya, Sri Lanka, saranandahewage@yahoo.com

Correspondence Authors– 1) M.A.D.D. Munasinghe,mdilushi@yahoo.com, +94 77 8085493.

2) K.F.S.T.Silva, frankserendib@gmail.com , +94 81 2395310