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Nutritional quality analysis of different Moringa provenance in Bale, Southeast Ethiopia

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ABSTRACT

Moringa is a tree with medicinal, nutritional, industrial, and socio-economic values. Moringa leaf extracts have potential antihypertensive, antispasmodic, antiulcer, diuretic, hepato-protective and cholesterol-lowering activities. The study was conducted to analyze the nutritional quality of different moringa provenances and to promote the best provenances for the end users. Field experiments were conducted in Goro and Dallo Mena districts of Bale located in Oromia regional state of Ethiopia. Collected samples were air-dried at room temperature and milled for laboratory analysis. According to this study growing environment did not bring significant variation ($P>0.05$) in average mineral contents like Mg, Zn, P and CP content of the provenances. But significantly higher ($P<0.05$) Na, K, and Ca were recorded for the samples collected from Dallo Mena district, whereas higher Ash and Fe content was recorded in Goro district. On the other hand, provenance from Dallo Mena and Bako is superior to most of the quality characters analyzed. However, the one from Arbaminch is higher in Na and Zn contents. Provenance from Abay Filiklik is higher in Ash, K and P content. Moringa leaf is rich in Ash, Zn, Cp, and Mg to the sufficient level, while Fe, Ca and P are to the level of high or double to triple to the optimum level when compared to the optimum nutrient content of plant material. Generally, higher mean and individual chemical quality values were recorded from provenances grown in Dallo Mena district except for K, Fe, Zn, and CP, which are higher in Goro.

Keywords: Chemical quality, Composition, Moringa leaf, Nutritional content, Provenances

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Introduction

Moringa is a miracle tree that plays multiple roles in supporting farmer's economy and health (Haile- Gabrieal, 2003). It is a versatile plant that can be grown as a tree or as a "perennial-vegetable" cultivated at home garden level by many smallholder farmers or under intensive cultivation. Moringa tree can grow up to 4 m in a year, reaching a height of 15 m, and can live for about 20 years (Doerr and Cameron, 2005). *Moringa oleifera* and *Moringa stenopetala* are the two most common species among the 13 species of the Moringa family. *M. oleifera* originates from the Himalayas, and *Moringa stenopetala* is endemic to East Africa (Grubben and Denton, 2004).

Moringa stenopetala is also a native tree in arid and semi-arid areas in the southern rift valley of Ethiopia and Northern Kenya (Yalemtsehay and Amare, 1998). It is also called in Amharic "Shiferaw" or cabbage tree. The local farmers use the species as a major arable tree inter-crop in the multi-storey system, especially by the Konso people in Gamo Gofa (Eshetu, 1998). *Moringa stenopetala* has a wide range of adaptations from arid to humid climates with a prospect to be grown in a wide range of land use classes (Dechasa *et al.*, 2006) where the potential growing area falls in a rainfall range from 300-1400 mm per year with soil reaction of 6-7 (Mayer, 1990).

All parts of the *Moringa* tree are edible and have long been consumed by humans. The leaves of the *Moringa oleifera tree* are very nutritious. They can be consumed in fresh, cooked, or dried way. Since dried *Moringa* leaves retain their nutrient content, converting them into powder form is possible. When leaves are abundant, this leaf powder can be made and stored easily. *Moringa* leaf powder is an excellent nutritional supplement and can be added to any dish (Doerr and Cameron, 2005). Leaves and pods of *Moringa oleifera* can be a precious source of

nutrition for people of all ages (Alessandro *et al.*, 2015). Ancient queens and kings used the fruits and leaves of this miracle tree in their diet to maintain mental alertness (Mahmood *et al.*, 2010). Nutritional analysis indicates that *Moringa* leaves contain many essential, disease-preventing nutrients. They even contain all essential amino acids, which is unusual for a plant source. Since the dried leaves are concentrated, they have higher amounts of nutrients except Vitamin C (Alessandro *et al.*, 2015).

The Moringa species is a fast-growing, multi-purpose tree that provides food, fuel, and fodder that grow in semi-arid and drought-prone areas. The tree is cultivated for its leaves that are boiled and eaten like cabbage and sold in local markets (Edwards *et al.*, 2000). A recent study conducted by Melesse *et al.* (2009) indicated that the leaves of *Moringa stenopetala* are rich in protein (28.2%) and contain reasonable amounts of essential amino acids comparable with those found in soybean meal. The leaves are also high in nutrients such as fiber and minerals like calcium, Irion, vitamin A and vitamin C, and other organic compounds with incredible health benefits. Therefore, it can make a significant contribution to nutritionally poor diets. The Moringa tree has many benefits, but the health benefits are the most important. *Moringa* is effective against skin infections, lowering blood sugar, reducing swelling, healing gastric ulcers, lowering blood pressure, and even calming the nervous system (Fuglie, 2001). The leaves of M. *stenopetala* contain different important phytomolecules such as alkaloids, flavonoids, phenolic compounds, glycosides, saponins, and glucosinolates (Geleta *et al.*, 2016). In addition to this *M. stenopetala* leaves have antihyperglycemic, antihypertensive, antihyperlipidemic, and diuretic activities, which are very important for human health (Fekadu *et al.*, 2017).

Moringa is one of the known tree species which has been used as food in different places. Based on this concept, to expand the plantation of this species and to promote new Moringa provenances, the adaption trail of other Moringa provinces' was conducted in Dallo Mena and Goro districts of Bale for about four years. Knowing the nutritional quality of the adapted provenances is very important to recommend for the end users. With this justification, this study was initiated to analyze the nutritional quality of different Moringa provenances and to promote the best provenances for the end users.

Materials and Methods

The study was conducted in the Oromia regional state of Ethiopia Bale districts. The area is located in South-eastern part of the country. Specifically, the study was conducted in Dallo Mena and Goro districts of Bale. The study area is located in the midlands agro ecology areas of Bale with a bimodal rainfall pattern. The altitude of the area is 1285 m.a.s.l for Dallo Mena and 2732 m.a.s.l for Goro districts. The locations are known for mixed farming systems, where cereal is the dominant cultivated crop (Bikila *et al.*, 2020).

Leaf samples for laboratory analysis were collected from tree adaptation sites (Goro and Dallo Mena districts) after pruning and regeneration for three months. Those Provenances include; *Moringa stenopetala* (Dello Mena), *Moringa stenopetala* (Abay Filikilk), *Moringa stenopetala* (Arbaminch) and *Moringa oleifera* (Bako).

Data collection

Collected samples were air dried at room temperature and milled with coffee Miller and made to pass through a 1 mm standard sieve. Moringa quality assessment was carried out in the laboratory based on the following procedure.

Ash content: The ash content was determined gravimetrically in accordance to AACC (2000) method 08-01. About 3 g of Moringa flour sample was weighed on a pre-ignited and cooled procaine crucible. The sample washes in a muffle furnace adjusted to 525°C for three hours. After cooling in desiccators, % ash was calculated from the mass difference on a dry matter basis.

Moisture Content: The moisture content was determined by the hot air oven method as described by AOAC (2005) by taking 3 g sample into an empty moisture dish and made dry in a hot air oven for 12 hours at 105 °C and the moisture content was calculated as the loss in weight.

Fiber Content: Fiber content was determined according to AACC method 32-05. One gram of samples was weighed in pre-weighed crucibles, digested for 5 minutes with acetone, and filtered using a cold extractor unit to wash the oil. The sample was then transferred to a hot extractor unit, digested for 30 minutes with 1.25% (0.255 + or - 0.005 N) H2SO4, and then filtered. After digestion with acid and filtration, 1.25% (0.313 + or – 0.005 N) NaHO was added, digested for 30 minutes, and filtered. The samples were rewashed with acetone to remove the remained oil and then dried and weighed. Then samples were ashed at 550°C in a muffle furnace and weighed. The fiber content was calculated as the difference between the dried and ashed divided by the initial sample as:

$$\% \text{ Fiber} = \frac{\text{Dried weight of sample} - \text{Ashed wt of Sample}}{\text{Inital wt of Sample}} * 100$$

Crude protein content: Crude protein content was determined by the micro-Kjeldahl procedure by taking about 0.5 g flour samples using a K_2SO_4- $CuSO_4$ catalyst according to AACC (2000) method 46-12. Finally, the amount of nitrogen was calculated according to the formula below, and the protein content was calculated using the conversion factor.

$$\% N = \frac{x \text{ moles}}{1000 \text{ cm}^3} \times \frac{(v_s - v_b) \text{ cm}^3}{m \text{ g}} \times \frac{14 \text{ g}}{\text{moles}} \times 100$$

Where, Vs and Vb are the titration volumes of the sample and blank, and 14 g is the molecular weight of nitrogen N. The protein contents of the samples were calculated as follows:

$$\% \text{ Protein} = F * \%N$$

Where, F is the conversion factor, and %N is the percent of nitrogen content.

Fat Content: Fat was determined using the continuous solvent extraction gravimetric method using an automatic fat determinator, as described by Pike (2003). Samples were weighed into extraction thimble and covered with cotton wool. The recovering flask was weighed, and about 50 ml of organic solvent (diethyl ether) was poured into the extraction cup and inserted into the extractor. The extract obtained was dried in a hot air oven at 110 ^{0}C for 45 minutes and held in desiccators for cooling, after which it was weighed.

The fat content will be calculated as

$$\% \text{ Fat} = \frac{\text{wt of fat}}{\text{Original wt of the sample}} * 100$$

Carbohydrate Content: The carbohydrate content of samples was obtained by subtracting the sum of the other proximate result from one hundred.

Carbohydrate (%) = 100 – (% Ash + % Fat + % moisture+ % protein + % fiber).

Mineral Content: The mineral content of Moringa samples was determined using the method described by AOAC (1998). The ash obtained from the ash analysis earlier was used to determine the mineral content. The ash in the porcelain crucible was dissolved with a few drops of distilled water, followed by 5 ml of 2N hydrochloric acid, and filtered through Whiteman filter paper into a 100 ml volumetric flask. The minerals, such as calcium (Ca), Magnesium (Mg), Zinc (Zn), and Iron (Fe), were determined using Atomic Absorption Spectrometer. In contrast, Sodium (Na) and Potassium (K) were determined using a Flame photometer. In comparison, phosphorous (P) content was determined using a spectrophotometer.

Data analysis

All collected data were subjected to the analysis of variance (ANOVA) using SAS GLM procedure. The significance variation between mean values was expressed by the Least Significant Difference tests (LSD) of probability at 5% significance level.

Results and Discussion

Quality Characters of Moringa Provenances

For Moringa provenances grown in Goro district, all quality characters except Magnesium(Mg), Iron(Fe), and Phosphorous(P) contents have shown significant variation (P<0.05) (Table 1). At Goro district, the highest %MC (7.43), %Ash (11.31), %Mg (0.197), Fe (180.70 ppm), and protein% (24.12) content were recorded by Moringa provenance collected from Bako *(M. oleifera*). Even though it is comparable, *Moringa oleifera* has the highest nutrient contents compared to *Moringa stenopetala*. Even in terms of their composition of minerals like Mg, Fe and P, both types of Moringa species are not significantly varied (P>0.05). Higher Na, and K, was recorded by the three *Moringa stenopetala* provenances collected from different location of the country. While the smallest was for *M. oleifera* collected from Bako.

For Ca, the highest (2.92) content was recorded from the Moringa provenance collected from Bako *(M. oleifera*). Even though there is no significant difference between the provenances, the highest Fe and P value were recorded from Moringa provenance collected from Bako (*M. oleifera*) (180.57 ppm) and Moringa provenance collected from Abay Filiklik (*M. stenopetala*) (646 ppm). For Zn, there is a significant difference between the provenance, and the highest content was recorded (44.56 ppm) for Arbaminch, and the lowest (29.22 ppm) is for the collection from Bako (*M. oleifera).* Fat, fiber and carbohydrate contents of Moringa provenances also showed a significant variation at Goro. Collection from Dallo Mena brought about the highest Fiber and carbohydrate content (7.10 and 51.65%), respectively, while higher fat (6.70%) was recorded by *Moringa oleifera (*Table 2).

Table 1. Physico-chemical quality characters of moringa provenances grown at Goro district.

Provenance	% MC	% Ash	Na ppm	% K (g/100g)	% Mg (g/100g)	% Ca (g/100g)	Fe ppm
Arbaminch	6.55±0.13^b	9.80±0.48^b	706.67±281.84^a	0.30±0.02^a	0.177±0.03	2.180±0.29^b	177.20±9.88
AbayFiliklik	6.27±0.35^b	9.06±0.17^c	560.00±235.16^a	0.33±0.05^a	0.184±0.02	1.872±0.33^b	173.63±41.63
Bako	7.43±0.35^a	11.31±0.44^a	168.00±34.77^b	0.23±0.09^b	0.197±0.019	2.920±0.22^a	180.57±33.35
Dallo Mena	6.69±0.29^b	9.31±0.20^{bc}	393.33±102.14^{ab}	0.30±0.02^a	0.154±0.030	2.206±0.37^b	157.07±12.27
Mean	6.74±0.51	9.87±0.96	457.00±265.31	0.29±0.045	0.176±0.027	2.295±0.48	172.12±25.52
CV (%)	4.41	3.59	21.86	9.41	15.31	13.35	16.16
LSD (0.05)	0.56	0.67	360.18	0.054	(ns)	0.577	(ns)

MC; Moisture Content, Na; Sodium, K; Potassium, Mg; Magnesium, Ca; Calcium, Fe; Iron

Table 2. Some of the quality characters of moringa provenances grown under Goro condition.

Provenance	Zn ppm	%CP	P ppm	% Fiber	% Fat	Carbohydrate	Calorie
Arbaminch	44.56±2.78^{a}	24.19±0.75^{a}	643.78±58.55	6.53±0.32^{ab}	4.94±0.51^{b}	47.98±0.41^{b}	333.18±2.67
AbayFiliklik	35.22±4.75^{bc}	22.46±0.60^{a}	646.16±103.80	6.90±0.58^{a}	5.21±1.38^{ab}	50.09±1.46^{ab}	337.12±6.14
Bako	29.22±3.94^{c}	24.12±0.36^{a}	593.71±68.24	5.62±0.88^{b}	6.70±0.65^{a}	44.82±0.89^{c}	336.03±5.10
Dallo Mena	39.54±3.87^{ab}	20.08±2.30^{b}	574.63±25.87	7.10±0.64^{a}	5.17±0.69^{ab}	51.65±2.72^{a}	333.45±5.85
Mean	37.14±6.76	22.71±2.05	614.57±67.89	6.54±0.81	5.51±1.04	48.64±3.01	334.94±4.71
CV (%)	10.49	5.54	11.37	9.79	11.92	3.33	1.53
LSD (0.05)	7.34	2.37	NS	1.21	1.65	3.05	NS

Zn; Zinc, CP; Crude Protein, P; Phosphorous
NS = Non significant

The result from Dallo Mena also shows significant variation was observed due to Moringa provenances except for a few minerals like Ca, Zn and Cp content. *Moringa oleifera* (Collection from Bako) brought about the highest and most significant (P<0.05) for MC (11.52%), Ca (3.07), P (729.61 ppm) and Fat (5.99%) contents. Higher Ash (9.25%), Na (916.67 ppm), K (2.9%), Fe (115.03 ppm), Fiber (7.55%) and higher but non-significant (P>0.05) Zn (36.12 ppm) content was recorded by Moringa collection form Abay Filiklik. In contrast, the lowest protein (20.36 %), K (1.87%), P (423.22 ppm) and Fat (2.96%) content was recorded by provenance from D. Mena (Table 3 and 4). On the other hand, *Moringa oleifera* shows the lowest results concerning Na (520 ppm), Mg (0.15%), Fe (78.40 ppm), Fiber (6.29%), Carbohydrate (44.89%) and total calorie (44.89) composition.

All quality characters measured except for Ca, Zn and CP, the other quality parameter have shown significant variation (P<0.05) for Moringa Provenances grown at Dallo Mena. The highest %MC (11.52%), CP (23.60%), and Fat (5.99 %) content were recorded for Moringa provenance collected from Bako (*M. oleifera*). Provenance collected from Arbaminch also got higher sodium and Mg content. On the other hand, provenance from Dallo Mena got lower results in most quality characters (Table 3 and 4).

Table 3. Some of the quality results of moringa provenances grown under Dallo Mena condition.

Provenance	% MC	% Ash	Na ppm	% K (g/100g)	% Mg (g/100g)	% Ca (g/100g)	Fe ppm
Arbaminch	6.04±1.03^{b}	6.49±0.83^{b}	916.67±97.13^{a}	2.51±0.53^{ab}	0.23±0.03^{a}	2.78±0.87	91.80±15.06^{ab}
Abay Filiklik	5.51±0.38^{b}	9.25±0.22^{a}	916.67±175.59^{a}	2.90±0.26^{a}	0.21±0.05^{ab}	2.87±0.89	115.03±6.03^{a}
Bako	11.52±0.33^{a}	7.71±0.40^{b}	520.00±60.00^{b}	2.47±0.25^{ab}	0.15±0.018^{b}	3.07±0.52	78.40±4.87^{b}
Dallo Mena	7.19±1.38^{b}	6.91±1.12^{b}	886.67±41.63^{a}	1.87±0.04^{b}	0.19±0.04^{ab}	2.80±0.72	99.05±22.98^{ab}
Mean	7.56±2.58	7.59±1.26	810.00±197.58	2.436±0.52	0.19±0.04	2.88±0.66	96.07±18.41
CV (%)	11.83	9.63	13.18	15.84	19.39	26.61	14.86
LSD (0.05)	1.89	1.38	201.03	0.73	0.07	NS	26.88

MC; Moisture Content, Na; Sodium, K; Potassium, Mg; Magnesium, Ca; Calcium, Fe; Iron

Table 4. Some of the quality results of moringa provenances grown under Dallo Mena condition.

Provenance	Zn ppm	% CP	P ppm	% Fiber	% Fat	Carbohydrate	Calorie
Arbaminch	33.87±9.96	20.36±4.01	566.29±117.88^{ab}	6.44±0.50^{b}	3.29±1.23^{b}	57.37±5.36^{a}	340.52±5.30^{a}
Abay Filiklik	36.12±5.74	22.71±7.60	755.84±117.01^{a}	7.55±0.56^{a}	3.98±0.38^{b}	51.01±7.87^{ab}	330.69±1.70^{b}
Bako	33.16±1.83	23.60±3.14	729.61±108.54^{a}	6.29±0.17^{b}	5.99±1.34^{a}	44.89±2.78^{b}	44.89±6.25^{b}
Dallo Mena	29.78±5.69	21.37±6.89	423.22±64.21^{b}	6.85±0.39^{ab}	2.96±0.68^{b}	54.71±6.95^{ab}	330.99±3.71^{b}
Mean	33.23±6.01	22.01±5.05	618.74±166.02	6.78±0.63	4.05±1.49	52.00±7.11	332.52±6.33
CV (%)	19.50	26.01	16.85	6.37	24.33	11.64	1.38
LSD (0.05)	NS	NS	196.33	0.81	1.86	11.40	8.62

Zn; Zinc, CP; Crude Protein, P; Phosphorous

Effect of growing environment on Moringa nutritional quality

The growing environment has brought about significant variation (P>0.05) in the average mineral contents of MC, Ash, Na, K, Ca, Fe, and Fat. Significantly higher (P<0.05) MC, Na, K, and Ca values were recorded for the provenances grown in Dallo Mena, while higher Ash, Fe and Fat content was recorded for the one grown in Goro. The overall result shows strong and significant environmental effects were observed on most Moringa-quality characters. Combined over location result shows there is no significant (P>0.05) variation in Mg, Zn, CP, P, Fiber, Carbohydrate, and Calorie between Moringa provenances across the environment (Table 5 and 6).

Table 5. Effect of Growing Environment on quality characters measured.

District	% MC	% Ash	Na ppm	% K (g/100g)	% Mg (g/100g)	% Ca (g/100g)	Fe ppm
Dallo Mena	7.56±2.58[a]	7.59[b]	810.00[a]	2.43[a]	0.19	2.88[a]	96.07[b]
Goro	6.74±0.51[b]	9.87[a]	457.00[b]	0.29[b]	0.18	2.29[b]	172.12[a]
Mean	7.15±1.87	8.73	633.50	1.36	0.19	2.59	134.09
CV (%)	6.50	6.58	24.45	20.06	17.67	22.56	16.48
LSD (0.05)	0.58	0.50	134.07	0.24	NS	0.51	19.13

Table 6. Effect of Growing Environment on quality characters measured.

Location	Zn ppm	% CP	P ppm	% Fiber	% Fat	Carbohydrate	Calorie
Dallo Mena	33.23	22.01	618.74	6.78±0.63	4.05±1.49[b]	52.00±7.11	332.52±6.33
Goro	37.14	22.71	614.57	6.54±0.81	5.51±1.04[a]	48.64±3.01	334.94±4.71
Mean	35.18	22.36	616.65	6.66±0.72	4.78±1.46	50.32±5.61	333.73±5.60
CV (%)	15.19	18.54	14.39	10.84	26.89	10.85	1.67
LSD (0.05)	NS	NS	NS	NS	1.09	NS	NS

All Moringa provenance leaves seem to be a good source of crude protein and most minerals that are very important in the human diet. The nutrient composition of Moringa provenances considered in the current study is comparable with the finding of most scholars.

According to Temam and Nuredin (2017), the mean moisture content of *Moringa Stenopitala* species is 7.5%, 27.5% protein, 2% Ca, and more or less in a similar range in other minerals, which is comparable with the findings of this study. Numerous researchers also reported the chemical composition of Moringa leaves. In this regard, the tree consists of essential chemicals with high nutritional value, which is very important for people of all ages (Dechasa *et al*., 2006).

For 1-3 years child aged, daily requirements of calcium, about 75% of iron and half of protein need scan be compensated by serving only 100 g of fresh leaves with optimal nutrient content. These all imply the extraordinary nutritional properties of Moringa trees; due to this, it can be used as a nutritional supplement, particularly in infants and pregnant/nursing mothers, to challenge malnutrition in tropical regions (Yisehak *et al*., 2011).

According to Hradesh *et al.* (2019), dried Moringa leaf powder exhibited ash content 9.53% and crude protein 20.42%. In contrast, the predominant mineral elements in the dried moringa leaf powder were Ca, Mg, K, Fe, 20.32, 387.83, 1545.33, 26.69, mg/100g, respectively. Other studies have reported variable protein contents between 16 and 27.4 (Oduro *et al*., 2008). So the results reported by most scholars are aligned with the finding of this study. The nutrient content of the Moringa provenances from both locations is double to triple the mean nutrient composition of plant material. At the same time, in other cases, it is optimal or above (Table 7).

Table 7. Different Nutrient contents of plant materials in %.

Nutrient	Deficient	Low	Sufficient	High
Nitrogen %	<1.25	1.25-1.74	1.75-3.0	>3.0
Phosphorous %	0.15	0.15-0.19	0.2-0.50	>0.5
Potassium %	<1.25	1.25-1.49	1.50-3.0	>3.00
Calcium %		<0.20	0.2-0.50	>0.50
Magnesium %		<0.15	0.15-0.50	>0.50
Sulfur %		<0.15	0.15-0.4	>0.40
Protein %	<7.51	7.50-10.90	10.90-18.75	>18.80
Copper (ppm)		<5	5-25	>25
Manganese (ppm)	<5	5-24	25-100	>100
Zinc (ppm)		<15	15-70	>70

Source: Walsh and Beaton (1973)

On the other hand, the provenance of Dallo Mena and Bako is superior to most of the quality characters analyzed. However, the one from Arbaminch is higher in Na and Zn content. Provenance from Abay Filiklik is higher in ash%, %K and P content. According to Walsh and Beaton (1973), all the chemical/nutritional characteristics measured varied from sufficient to high, as indicated in Table 7.

Conclusion

The result of this experiment clearly shows that Moringa is rich in nutrient content compared to other cereal and root crops. All measured nutritional characteristics fall under sufficient to high levels. It is especially rich in ash, Zn, Cp, and Mg to an adequate level. For Fe, Ca and P, there is a double to triple nutrient level as compared to plant material composition standard. Therefore, it is possible to use Moringa flour for food fortification, especially for minerals like Ca, Fe and phosphorous. Generally, higher mean and individual chemical quality values were recorded from provenances grown in Dallo Mena district except for K, Fe, Zn and CP, which is higher in Goro. The chemical analysis for the plant material collected from Dallo Mena provenances falls under good to best nutrient composition levels. Therefore, it is good to recommend all the provenances for expansion if the provenances are adaptive and the physiological data of the crop

fits the quality characteristics. Finally, further study is essential to evaluate the change in the nutritional composition of Moringa in different age categories and maturity levels.

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