LIFE Project Number

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LIFE PROJECT NAME or Acronym

LIFE-F4F (Food for Feed)

	Annex Data
Action:	B4 Evaluating the Produced Feed for Pigs and Poultry Husbandry
Partner:	AUA
Deliverable:	B4.2 Indications of shortcomings of the production process, in relation to the product's use for pigs and poultry husbandry, and suggestion for improvements.

Table of contents

1. ACTION B.4.: Evaluating the Produced Feed for Pigs and Poultry Husbandry

1. Introduction

Food waste may be a potential feed for animals since it is a valuable source of energy, protein, minerals and vitamins. Recently, the use of food waste in animal diets has gained considerable attention. Many poultry and pig producers become increasingly attracted to seek to use food waste as feed due to the increasing prices of conventional arable based animal feeds.

The aim of the present trial was to investigate the effect of adding dried food waste collected from hotels to the diet of broilers and fattening pigs. In those food waste was included feed with animal origin lefts (e.g. dairy products, meat), feed without meat lefts, feed was sterilized with different chemical compositions. All the above products have significant importance and value as animal feeds, despite their variable content in energy, protein, aminoacids, minerals, vitamins and rest nutrients.

Food waste lefts from hotels and restaurants are quite safe from hygiene point of view, if they have been preserved in the right way as it is suggested, and their chemical compositional analysis, it is concluded that this final dry feed produced is safe, of relatively high nutritional quality, proper to be used as a simple ingredient, like any other feed, in animal diets. As all the other feeds, each individual product has its own nutritive value, related to initial food waste lefts composition, and thus it can be used as simple ingredient, combined with other ingredients too in the diets of productive animals (like pigs, poultry, fur animals) and pets (dogs, cats). The inclusion percentage of each such product, will depend on its chemical composition, animal species, productive (physiological) stage of the animal (related to its nutritional requirements), available quantities, and the market price of the other available feeds.

2. Activity B.4.2.: Animals feeding trials

Deliverable 2. Indications of shortcomings of the production process, in relation to the product's use for pigs and poultry husbandry, and suggestion for improvements.

B.4.2.1. First experimental trial for broilers

Two hundred (200), male, day-old, Aviagen Ross 308 broilers were used in total. The broilers were obtained from a commercial hatchery. The duration of the experiment was 42 days with housing and care of broilers, conforming to the guidelines of the Ethical Committee of the of the Agricultural University of Athens and complying with directive 2010/63/EC on the protection of animals used for scientific purposes.

Pen was the experimental unit. There were ten replicate pens of two (2) dietary treatments namely control (C) and treatment (T). There were 10 broilers per pen, 100 per treatment. Birds were assigned to a pen (2 m^2) with wheat straw shavings litter. The maximum stocking density in the pens did not at any time exceed 33 kg/m^2 following EU directive 2007/43/EC. In house environmental conditions (light and ventilation) were controlled. Heat was provided with a heating lamp per pen.

Broilers were fed three different diets, namely starter (0 - 10 days), grower (11 - 24 d) and finisher (25 - 42 d). In C treatment, broilers were fed a basal diet based on corn and soybean meal with no feed waste product added. In T treatment, product was added to starter, grower and finisher diet at a level of 15%.

Feed and water were provided *ad libitum*. Diets were isonitrogenous and isocaloric and met Ross Recommendations. The experimental diets are presented in Table 1.

Table 1. Composition (%), determined and calculated analysis of the experimental broiler diets

Ingredients	Control Starter	Treatment Starter	Control Grower	Treatment Grower	Control Finisher	Treatment Finisher
Food waste	-	15	-	15	-	15
Maize	48.50	45.14	52.12	47.97	57.62	53.47
Soybean meal	42.83	34.21	38.98	31.19	33.43	25.64
Vitamin and Mineral Premix[1]	0.20	0.20	0.20	0.20	0.20	0.20
Limestone	0.84	0.55	0.78	0.48	0.74	0.45
NaCl	0.37	0.07	0.37	0.07	0.37	0.07
Methionine	0.36	0.39	0.31	0.33	0.27	0.28
Soybean oil	4.46	1.64	5.17	2.45	5.59	2.86
Lysine	0.24	0.37	0.17	0.28	0.16	0.27
Threonine	0.10	0.24	0.07	0.11	0.04	0.09
Monocalcium P hosphate	2.02	2.06	1.76	1.80	1.50	1.54
Choline	0.08	0.13	0.07	0.12	0.08	0.13
Determined composition (%)						
Dry matter	88.74	88.55	89.23	88.45	89.30	89.25
Ash	5.87	5.60	5.52	5.25	4.95	4.47
Crude protein	22.82	22.69	21.98	21.02	18.88	18.67
Ether extract	5.88	6.02	6.32	7.09	7.25	7.71
Crude fibre	4.00	4.01	3.82	3.66	3.29	3.02
Calculated Analysis						
ME (MJ/kg)	12.55	12.55	12.97	12.97	13.39	13.39
Sodium (g/kg)	1.6	1.6	1.6	1.6	1.6	1.6
Ca (g/kg)	9.6	9.6	8.7	8.7	7.8	7.8
Available P (g/kg)	4.8	4.8	4.4	4.4	3.9	3.9
Lysine (g/kg)	14.4	14.4	12.9	12.9	11.5	11.5
Methionine+ cysteine (g/kg)	10.8	10.8	9.9	9.9	9.0	9.0
Threonine (g/kg)	9.7	10.5	8.8	8.8	7.8	7.8

[1]Premix supplied per kg of diet: 13,000 IU vitamin A (retinyl acetate), 3,500 IU vitamin D_3 (cholecalciferol), 70 mg vitamin E (DL-α-tocopheryl acetate), 7 mg vitamin K_3, 8.5 mg thiamin, 8 mg riboflavin, 5 mg pyridoxine, 0.020 mg vitamin B_{12}, 50 mg nicotinic acid, 15 mg pantothenic acid, 1.5 mg folic acid, 0.15 mg biotin, 1 mg iodine, 50 mg iron, 75 mg manganese, 15 mg copper, 0.3 mg selenium, 75 mg zinc

Sampling

On onset and at the end of each phase, broilers body weight (BW) was recorded and the mean body weight gain (MBWG) was calculated. Furthermore, feed intake was measured (MFC) and feed conversion ratio (FCR) was calculated. Broilers were inspected daily and any mortality was recorded.

At the end of the 6th week, a representative number of chickens per treatment was sacrificed to investigate treatment effects on carcass yield and carcass quality (pH, colour, cooking loss and shear force). Furthermore, blood samples were collected for determination selected haematological and biochemical parameters most notably haematocrit (%), aspartate aminotransferase (SGOT-AST) (IU/l), alanine aminotransferase (SGPT-ALT) (IU/l), blood urea nitrogen (BUN) (mg/dl), γ-glutamyltransferase (γ-GT) (IU/l), alkaline phosphatase (IU/l), cholesterol (mg/dl), total proteins (g/dl) and fractions of albumins (g/dl) and globulins (g/dl). Internal weight of selected organs (heart, spleen, liver, kidney, bursa of Fabricius and Gizzard) was determined and expressed as percentage of final body weight.

The pH24 was measured with the electrode inserted into the right section of the breast muscle 24 h post-mortem. Meat colour was measured using a chromameter set on the L* (lightness), a* (redness), b* (yellowness) system. White and black tiles were used as standards. The right breast muscle from each chicken was weighed, placed into a plastic bag and cooked in a water bath at 85°C for 30 min, then left under running water for 15 min and equilibrated at room temperature. The sample was weighed again to estimate the percentage of cooking loss (%). Shear force was evaluated using a testing machine (Zwick Testing Machine Model Z2.5/TN1S; Zwick GmbH & Co, Ulm, Germany) equipped with a shear blade (Warner-Bratzler G146; Instron, Grove City, PA, US). Peak force values in N/mm2 were recorded.

Broiler's Performance

Broiler's performance is reported in Table 2. Overall, broilers performed well. Broilers fed the treatment diet had lower weight gain and feed intake, but final FCR did not differ between treatments. There was a tendency for lower mortality in broilers of the treatment group. Carcass yield was high, more than 75% and did not differ between treatments.

Table 2. Performance of broilers

	C	T	SEM	P- value
Initial BW (g)	40.05	39.75	0.25	NS
Final BW 42d (g)	3098.2	2794.1	49.99	<0.001
MBWG (g)	3058.1	2754.3	50.03	<0.001
MFC (g)	4586.9	4289.6	73.94	0.011

	C	T	SEM	P- value
FCR	1.50	1.56	0.021	NS
Mortality %	7	2	1.78	0.072
Carcass yield (%)	75.78	75.60	0.250	NS
Breast yield (%)	29.48	30.28	0.376	NS

Values are means of ten replicate pens (n = 10). BW: body weight of broilers; MFC: Mean feed intake of the total experimental period (0-42 days); MBWG: Mean body weight gain of the total experimental period (0-42 days); FCR: Feed conversion ratio (g feed/g gain) of the total experimental period (0-42 days); NS: Statistically non significant.

Body weight between treatments did not differ significantly on day 0, 10, and 24 but final body weight was statistically different at day 42. Similar trend was noticed for weight gain and feed consumption during final phase (25-42 days), indicating that broilers fed the food waste had lower body weight gain and higher feed intake. In conclusion, the broilers of the control group, for the whole experimental period, had higher body weight gain and feed intake, compared to those of the treatment group, but with no difference in feed conversion ratio.

Internal organ weight and Haematological Parameters

Several biochemical and haematological parameters as well as internal organ weight as percentage of final body weight were examined in order to investigate potential effects on broiler's health. Data are presented in Table 3. No major differences were detected.

Table 3. Treatment effects on internal organ weight and selected biochemical and haematological parameters

	C	T	SEM	P-value
Heart (%)	0.507	0.505	0.017	NS
Spleen (%)	0.097	0.096	0.008	NS
Liver (%)	1.60	1.59	0.045	NS
Kidney (%)	0.159	0.157	0.010	NS
Bursa of Fabricius (%)	0.199	0.194	0.018	NS
Gizzard (%)	1.25	1.22	0.066	NS
SGOT AST(IU/l)	522.3	519.3	85.74	NS
SGPT ALT (IU/l)	5.50	4.70	0.858	NS
BUN (IU/l)	1.41	0.98	0.176	NS
γ-GT (IU/l)	22.30	23.10	2.520	NS
Phosphatase (IU/l)	3207.0	2260.8	400.2	NS
Cholesterol (mg/dl)	143.3	157.5	4.758	0.049
Total proteins (g/dl)	2.80	2.71	0.087	NS
Alboumin (g/dl)	1.19	1.22	0.038	NS
Globulin (g/dl)	1.61	1.49	0.060	NS
Haematocrit (%)	29.56	29.50	1.470	NS

Values are means of ten replicate pens (n = 10). NS: Statistically non significant

Carcass Quality

Examined parameters of carcass are reported in Table 4. No major differences were observed. Minor differences on colour traits and the shear force were observed. Fatty acid results are presented in Table 5.

Table 4. Treatment effects on selected parameters of carcass quality

	C	T	SEM[1]	P-value[2]
Color traits[3]				
L*	56.22	54.18	0.840	0.094
a*	6.06	5.70	0.270	NS
b*	17.43	15.84	0.474	0.023
Physical traits				
pH_{24}	6.22	6.21	0.026	NS
Cooking loss (%)	13.62	12.98	0.644	NS
Shear force (100N/mm²)	11.81	10.85	0.504	0.081

[1]Standard error of means
[2]P- value of ANOVA.
[3]L= lightness (L* 0= dark meat, L* 100= white meat), a*= redness (high a* value indicates red color, low a* value indicates green color), b*= yellowness (high b* value indicates tendency to yellow, low b* value indicates tendency to blue).*

Effects of diet on total fatty acids and main fatty acid (FA) classes (% of total FA) of breast in 42 day-old broilers shows statistical significant results for the concentration of saturated, polyunsaturated, monosaturated and n-6, n-3 fatty acids.

B.4.2.2. First experimental trial for fattening pigs

Twenty nine (19), castrated male, 106 day-old, Duroc×Landrace×Pietrain were used in total. Experiment last 46 days and all housing, caring and managing of pigs conforming with accordingly guidelines. Two dietary treatments namely control (C) and treatment (DFR: dried food residues) were created. There were 10 pigs in the control group and 9 in the treatment. The treatments were determined such as the BW of pigs were homogeneous. Individual cages were used for every pig equipped with plastic slatted floor and stainless steel nipple drinkers and feed troughs. The side panels of the cages were made of stainless steel and high endurance PVC. Environmental conditions (light and ventilation) were automatically controlled by the ventilation system, temperature and humidity were checked daily.

In C treatment, pigs were fed a basal corn-soybean meal based diet with no feed waste product added. In DFR treatment, product was added to the diet at a level of 10%.

Feed and water were provided *ad libitum*. Diets were formulated to meet the NRC (1998) recommendations for fattening pigs.

Sampling

Average daily body weight gain (ADWG), the average daily feed intake and the feed conversion ratio (FCR) were measured.

At the end of the trial (152 days of age), pigs were sacrificed to investigate treatment effects on carcass dressing percentage, as well as on meat quality indices (pH, colour, cooking loss and shear force). Furthermore, blood samples were collected for the determination of selected haematological and biochemical parameters.

Overall, pigs performed well with a final body weight similar among treatments. Average daily feed intake tended (P= 0.058) to be lower in DFR compared to C pigs. Average daily gain was lower (P= 0.027) in DFR compared to C pigs. However, feed conversion ratio was not affected by the treatment. Hot and cold carcass dressing percentage were high, more than 79% and 76%, respectively, reaching optimum commercial values, and were not affected by the dietary treatment. Meat color traits were not affected by the dietary treatment. Regarding meat physical traits, cooking loss and shear force were similar between C and DFR treatments, indicating that the addition of dried food residues to pig diets did not affect the water holding capacity and the tenderness, respectively. The only difference between treatments was found in ultimate meat pH value, which was lower (P= 0.007) in DFR treatment; nevertheless it was within the normal range of pork meat pH. No differences in the blood biochemical parameters between treatments were found, with the exception of SGOT and cholesterol level, which were higher (P= 0.003 and P<0.001, respectively) in the DFR when compared to C pigs. Effects of diet on total fatty acids and main fatty acid (FA) classes (% of total FA) broilers shows statistical significant results for the concentration of saturated and the fraction n-6/n-3.

B.4.2.3. Second experimental trial for broilers

Two hundred and forty (240), male, day-old, Aviagen Ross 308 broilers were used in total. The broilers were obtained from a commercial hatchery. The duration of the experiment was 42 days with housing and care of broilers, conforming to the guidelines of the Ethical Committee of the Agricultural University of Athens and complying with directive 2010/63/EC on the protection of animals used for scientific purposes.

Pen was the experimental unit. There were five replicate pens of four (4) dietary treatments namely control (C), non-meat treatment (NM), non-sterilized treatment (NS) and the sterilized treatment (S). There were 12 broilers per pen, 60 per treatment. Birds were assigned to a pen (2 m^2) with wheat straw shavings litter. The maximum stocking density in the pens did not at any time exceed 33 kg/m^2 following EU directive 2007/43/EC. In house environmental conditions (light and ventilation) were controlled. Heat was provided with a heating lamp per pen.

Broilers were fed three different diets, namely starter (0 - 10 days), grower (11 - 24 d) and finisher (25 - 42 d). In the C treatment, broilers were fed a basal diet based on corn and soybean meal with no food waste product added. In the NM treatment, food waste product with ingredients of plant origin was only added to starter, grower and finisher diet at a level of 10%. In the NS treatment, the food waste product was added to starter, grower and finisher diet at a level of 10%. Finally, the S treatment contained sterilized food waste product at a level of 10% in the starter, grower and finisher diet.

Feed and water were provided *ad libitum*. Diets were isonitrogenous and isocaloric and met Ross Recommendations.

Sampling

On onset and at the end of each phase, broilers body weight (BW) was recorded and the mean body weight gain (MBWG) was calculated. Furthermore, feed intake was measured (MFC) and feed conversion ratio (FCR) was calculated. Broilers were inspected daily and any mortality was recorded.

At the end of the 6th week, a representative number of chickens per treatment was sacrificed to investigate treatment effects on carcass yield and carcass quality (pH, colour, cooking loss and shear force). Furthermore, blood samples were collected for determination selected haematological and biochemical parameters most notably haematocrit (%), aspartate aminotransferase (SGOT-AST) (IU/l), alanine aminotransferase (SGPT-ALT) (IU/l), blood urea nitrogen (BUN) (mg/dl), γ-glutamyltransferase (γ-GT) (IU/l), alkaline phosphatase (IU/l), cholesterol (mg/dl), total proteins (g/dl) and fractions of albumins (g/dl) and globulins (g/dl). Internal weight of selected organs (heart, spleen, liver, kidney, bursa of Fabricius and Gizzard) was determined and expressed as percentage of final body weight.

Overall, broilers performed well. Broilers fed diets with non-sterilized and sterilized materials appear to have similar weight gain and feed intake with the control broilers. Furthermore, those fed the diet with non-meat had lower weight compared to the all other treatments. Dressing percentage was high, about 75%, with the exception of the non-meat treatment which was lower.

Several biochemical and haematological parameters as well as internal organ weight as percentage of final body weight were examined in order to investigate potential effects on broiler's health. No major differences were detected, among groups. For the meat quality traits no significant differences were observed among groups. The concentration of saturated fatty acids was higher in the control and NS treatments, the value of PUFA for NM was the higher. The fraction PUFA/MUFA tended to be high for C and NM treatment.

B.4.2.4. Second experimental trial for pigs

Twenty (20), castrated male, 113 day-old, Duroc×Landrace×Pietrain were used in total. All housing, caring and managing of pigs conforming with accordingly guidelines. Two dietary treatments namely control (C) and treatment (DFR: dried food residues with no meat) were created. There were 10 pigs in the control group and 10 in the treatment. The treatments were determined such as the BW of pigs were homogeneous. Individual cages were used for every pig equipped with plastic slatted floor and stainless steel nipple drinkers and feed troughs. The side panels of the cages were made of stainless steel and high endurance PVC. Environmental conditions (light and ventilation) were automatically controlled by the ventilation system, temperature and humidity were checked daily.

In C treatment, pigs were fed a basal corn-soybean meal based diet with no feed waste product added. In DFR treatment, product with no meat was added to the diet at a level of 8%.

Feed and water were provided *ad libitum*. Diets were formulated to meet the NRC (1998) recommendations for fattening pigs.

Sampling

Average daily body weight gain (ADWG), the average daily feed intake and the feed conversion ratio (FCR) were measured**.**

At the end of the trial, pigs were sacrificed to investigate treatment effects on carcass dressing percentage, as well as on meat quality indices (pH, colour, cooking loss and shear force). Furthermore, blood samples were collected for the determination of selected haematological and biochemical parameters.

Overall, pigs performed well with a final body weight similar among treatments. Average daily feed intake, average daily gain and feed conversion ratio was not affected by the treatment. Hot and cold carcass dressing percentage were high, reaching optimum commercial values, and were not affected by the dietary treatment. Meat colour traits were not affected by the dietary treatment. No differences in the blood biochemical parameters between treatments were found, with the exception of globulins that was higher for DFR treatment. Fatty acids concentrations did not show differences with the inclusion of food waste with no meat.

3. Conclusion

In conclusion, the use of these different food waste products can be promising feeds since the quality standards do meet diet requirements of at least productive animals like pigs and poultry, whose diets are formulated with feeds of plant and/or animal origin. The inclusion percentage of each of them in each diet will depend again on the diet needed to be formulated and the feed(s)' chemical, nutritional and economic value. In addition to those, it should be mentioned that any diet is supplemented with the 'missing' nutrients (e.g. aminoacids, minerals, vitamins) in order to be balanced and to meet the animal's requirements.

In particular, animals performed well after the inclusion of food waste and no negative effects were detected. The utilization of such products could be happened in industrial scale.