Encyclopedia of Feline Clinical Nutrition

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The feeding behavior of the cat

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Feeding behavior corresponds to all the motor sequences from the search for food, its recognition, acceptance and intake. It thus begins with exploration and ends with swallowing.

Although feeding behavior is well studied in domestication and production, only empirical data or anthropomorphic analysis is available for cats. Some recent scientific experiments, essentially performed by petfood manufacturers, are completing the scope of data available in pets.

The feeding and social behavior of cats differs greatly from dogs. Not only do their nutritional requirements differ, but the social structure of cats also results in different communication and feeding patterns both between cats and with their human caregivers. Meeting the nutritional needs of cats requires an understanding of their feeding ecology, nutritional needs and social communication and structure.

1 - Factors affecting the feeding behavior of the cat

► Hereditary determinants

> Sensorial aspects

Taste

The sensation of taste in a cat is present 5 days before birth *(Beaver, 1980)* and improves during life. The sensitivity differs between the 4 main types of taste perception, with the following hierarchy from the most to least stimulating (as demonstrated by the simple application of vinegar, salt, quinine, and sugar, on the tongue):

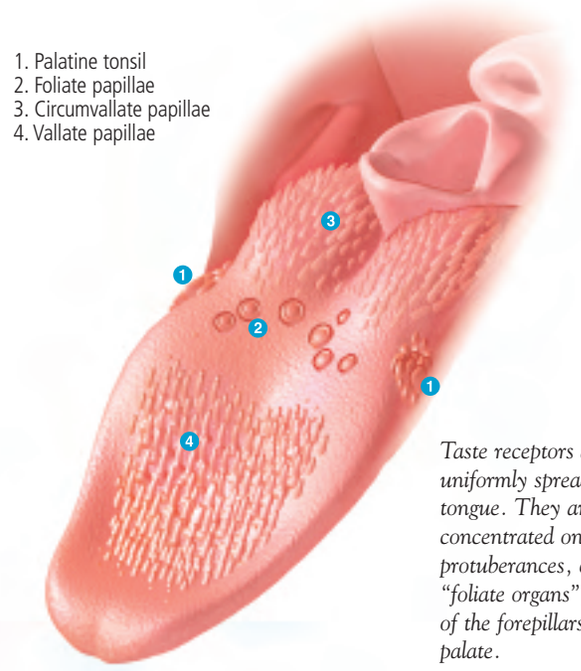
acid > bitter > salty > sweet

(Domestic cats are neither attracted to, nor show avoidance of the taste of sweet carbohydrates and high intensity sweeteners).

Our knowledge of taste has indeed evolved through the study of neurological signals in cranial nerves following the stimulation of the taste buds by different substances. Three cranial nerves are involved in taste. The facial nerves, in particular the chorda tympani, have undergone the most observations. This research has given rise to many theories. For example, *Boudreau* (1973,1977) presented a theory suggesting acid, amino acid and nucleotide taste systems specific to cats. This theory has not been confirmed by other authors.

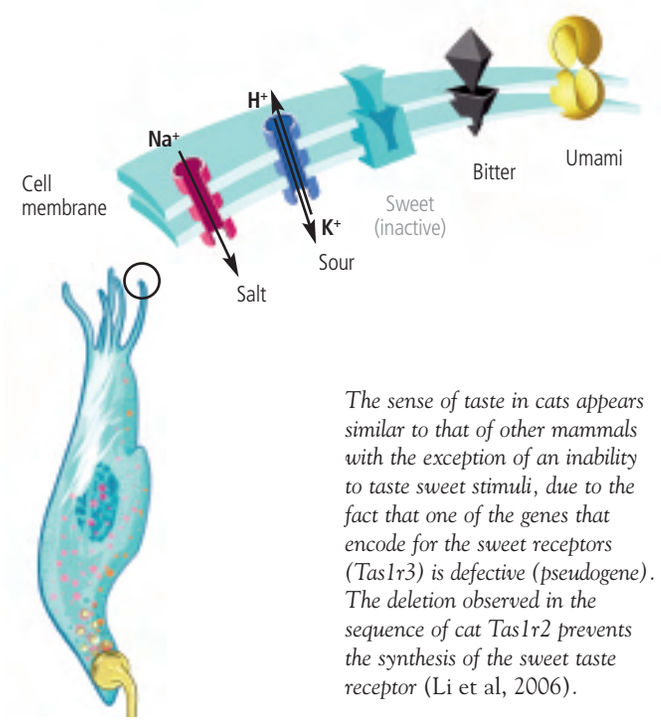
The number of taste buds is estimated at around 475 **(Figures 1 and 2)**. It is much less than dogs (1700) and man (9000). In dogs, gustatory cell turnover is around 4 days. No data is available in cats, but we may expect that it is similar. This data is interesting to evaluate appetite recovery after insult to the oral epithelium.

FIGURE 1 - LOCALIZATION OF THE TASTE RECEPTORS ON THE TONGUE OF THE CAT



Taste receptors are not uniformly spread over the tongue. They are mainly concentrated on two small protuberances, called "foliate organs", in front of the forepillars of the soft palate.

FIGURE 2 - DIFFERENT TYPES OF GUSTATIVE RECEPTORS



The sense of taste in cats appears similar to that of other mammals with the exception of an inability to taste sweet stimuli, due to the fact that one of the genes that encode for the sweet receptors (Tas1r3) is defective (pseudogene). The deletion observed in the sequence of cat Tas1r2 prevents the synthesis of the sweet taste receptor (Li et al, 2006).

Bitter taste
Bitter compounds easily trigger aversions. Bitter taste is due to a wide variety of components (tannins, alkaloids, malic acid, quinine, phytic acid, aminoacids such as tryptophan, isoleucine, leucine, arginine, phenylalanine, etc.).

Cats are very sensitive to bitter tastes *(Houpt, 2005)*. Cats are more sensitive than dogs to bitterness and detect it at lower concentrations. They can detect concentrations of bitter taste four hundred times smaller than levels detected by hamsters *(Carpenter, 1956; Houpt, 1991)*. This perception enables them to avoid many toxic substances (for example strychnine), which are often very bitter.

Sweet taste
Cats do not appear to care for sweet tastes: receptors have been deactivated. The corresponding gene exists but it has been switched off to a pseudogene *(Brandt, 2006)* through phylogenic adaptation *(Li et al, 2006)*. Cats tend to reject synthetic sweeteners like saccharine or cyclamate, since they are perceived as bitter *(Bartoshuk et al, 1975)*. The sweet taste of antifreeze appeals to dogs but not to cats. Rather, cats are typically poisoned by cleaning their paws after walking through the antifreeze.

Acid taste
This perceptiveness is widely used by petfood companies. Many commercially available cat food flavors indeed contain phosphoric acid. Excessive acid and phosphorus intakes must be avoided in cats with impaired renal function.

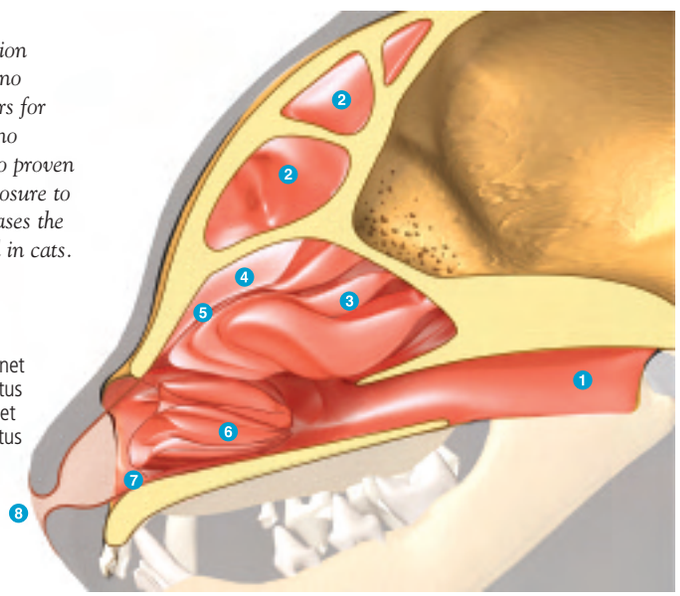
Salty taste
The perception is rather positive in cats and can enhance food or water consumption. Some water taste was hypothesized in early experiments, as taste receptors were thought to be reacting to distillated water. However, these electrophysiological responses were in fact the result of the adaptative neutrality of the cat's taste receptors to saline saliva.

Amino-acids
The taste buds connected to the facial nerve are highly sensitive to amino-acids: a single amino acid is able to stimulate the taste nerve fibers. These changes appear to be a specialization for feeding on prey, which is rich in protein *(Bradshaw et al, 1996)*.

FIGURE 3 - AIR CIRCULATION IN THE NASAL CAVITIES OF THE CAT

Unlike the perception of taste, there are no specialized receptors for smell. There are no published studies to proven that prolonged exposure to a given odor increases the detection threshold in cats.

1. Nasopharynx
2. Frontal sinus
3. Ethmoid sinus
4. Superior nasal cornet
5. Middle nasal meatus
6. Inferior nasal cornet
7. Ventral nasal meatus
8. Nostril



Oral sensitivity is not only gustatory, but somesthesia is important for granulometry and temperature detection through the lingual nerve. The ligaments of the teeth also participate. Any paradental disease or the effect of age, through modification of the resistance of the gums and teeth can strongly modify food perception and palatability.

It has been shown that the perception of food flavor is not simply the superposition of the various taste varieties but sensory messages are creating a brain image that is compared to innate or learned schemes *(Gallouin, 1987)*. However, no specific data exist for cats.

Olfaction

Olfaction is present at birth and matures by three weeks of age. The cat is less sensitive than the dog to smell. This difference in sensitivity is due to the

number of olfactory cells, rather than their density in the mucosa. Cats have between 60 and 70 million olfactory cells (compared to 80-220 in dogs). In some animal studies, it has been estimated that only 1% of volatile compounds enter the nasal mucosa **(Figure 3)** however, no direct data exist in cats.

The cat is very selective and cautious. Olfaction is THE key factor to trigger food acceptance. Any anosmia will prevent food intake, and this anorexia will last as long as the cat cannot smell *(May, 1987)*. Renewal of the olfactory mucosa and appetite recovery requires four to five days.

The range of smells perceived by cats is large but some specific odors are particularly attracting for them:
- mineral origin: bleach
- plant origin: catnip, olive wood, valerian, asparagus, mint, papyrus, cloves, mimosa
- animal origin: pheromones (although they do not have any direct food related meaning, but only territorial or sexual), livers, meats, viscera, etc.

However, detection ability does not mean food preference and no clear data exist on individual variability.
Some unusual odors or pheromones often trigger a specific reaction, called the Flehmen reaction, during which the cat lifts its upper lip and breathes some air through the vomero-nasal organ (Jacobson organ) located in the hard palate.

Petfood manufacturers are of course working on volatile compounds that are able to attract both the cat (when approaching its bowl) and the owner (when opening the can or the bag of kibble). However, as can be expected, this area of research remains very confidential and unpublished.

Vision

Lott-Brown et al (1973) have shown that cats are not able to discriminate between 520 and 570 nm lengthwaves. They thus would be unable to discriminate white from yellow or green. It would be for the cat the same "tonality". Red and blue are conversely clearly differentiated.
As a result, we may assume that colors of food are more important for owners than for cats.

The cat's vision is panoramic and adapted to discriminate movements more so than tonal differences. This ability has clearly evolved to facilitate predation.

> Behavioral aspects

Pre-natal experience

The acquisition of certain preferences may occur very early in life, as early as during gestation. Fetuses are surrounded by amniotic fluid, which contains compounds they assimilate in utero *(Thorne, 1994)*. A cat's gustatory system is functional in the final days of gestation *(Tichy, 1994)*.

Suckling behavior

Thanks to a burrowing reflex which lasts until the 8th day after birth, the new born kitten chooses a nipple during the first two days of its life. This reduces competition between littermates and decreases the time to initiate suckling *(Foucault, 1992)*. Temperature (of the skin) and olfactory stimuli (from Montgomery glands secretion around the nipples) are the most important after birth

The suckling reflex appears from the 50th day of gestation and is gone by the 23rd day of life.

© Yves Lanceau/RC/British Shorthair

There is nevertheless a maturation process during which regulatory factors transition from oral stimulation by milk up to the 10th day, to peri-oral stimulation (whatever the food is). The effect of digestive filling appears from 3 weeks of age.

The time allocated to suckling changes during the first month according to a relatively constant scheme. Kittens spend 10% of their time suckling and get milk for the first 2 weeks. Suckling time increases quickly up to 60% at 3 weeks and then decreases to 10% at the end of the first month *(Foucault, 1992)*. They also spend time to suckle without drinking any liquid.

The evolution of the kitten – mother bond around food evolves quite significantly during this time. During the first two weeks, 75% of the suckling periods are initiated by the queen. During the two following weeks, the proportion falls from 50 to 5%. The mother then begins to avoid her kittens and allocates them only 20% of her time. Weaning is in fact beginning, with major behavioral and digestive changes.

During lactation, the composition of milk varies with the mother's diet. Kittens may develop certain preferences at this time in their lives *(Thorne, 1994)*. Few articles describe this for cats. Weaning has in fact been more throughly studied.

Weaning experience

When eating their first solid food, kittens choose what their mothers eat, even if this food is unusual for cats *(Wyrwicka & Chase, 2001)*. Dietary preferences are thus not all innate; they are acquired through social influences after birth.

Kittens whose mothers have been conditioned to eat bananas (usually unpalatable for cats) will eat bananas during weaning even if they have access to more conventional food for cats such as kibbles *(Wyrwicka & Long, 1980)*. Kittens imitate their mother's eating behavior down to the smallest detail. They begin by eating from the same plate, at precisely the same spot, as their mother takes its food. There is a correlation between the mother's dietary consumption and that of the kittens. In the above experiment, the kittens that ate the least amount of banana were those whose mothers ate the least. The influence of the queen can last after weaning and separation between kittens and their mother. Food preferences acquired during weaning in their mother's presence persisted in kittens until the age of 4 to 5 months *(Wyrwicka & Long, 1980)*.

Weaning is an important time in an animal's dietary history. The moment a cat eats its first solid food is probably crucial in terms of influence, especially if it happens in their mother's presence.

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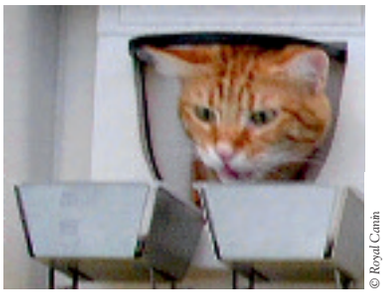
Kittens are more likely to eat a new and novel food when the queen is present than when she is absent *(Bateson, 2000)*. The illustration of the importance of the mother in food acceptance by kittens has also been illustrated in a trial from *Wyrwicka & Chase* (2001). Nineteen kittens from four litters were studied. Ten kittens ate in their mother's presence, while nine were without their mother during meals. The time it took kittens to accept a new food was very different between groups:

- for the kittens eating in their mothers' presence, it took an average of 5 hours for them to eat a new food
- in contrast, in the kittens separated from their mothers it took 4.8 days before they would eat a new food.

Therefore many dietary habits are determined before 6 to 8 weeks of age. The practical consequence is that food education must be done at this stage. A good idea is to select, at least for the first weeks after adoption, the food used by the breeder.

Individual and breed differences

Kittens fed by stomach tube have very limited gustatory experience compared to kittens fed normally. During conditioning tests in which success is rewarded with food, the kittens fed by stomach tube took longer to succeed and even refused to eat the reward *(Stasiak & Zernicki, 2000)*. Being deprived of dietary experience then influences future feeding behavior. All the early sensorial or digestive experiences create the individual variability. Learning leads to avoiding harmful or unpleasant foods and to preferably seek for nutritionally or sensorially gratifying ones.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One peculiar feature in cat palatability testing that offers the choice between two bowls, is that some tasters always choose one side, regardless of the diet inside the bowl. Some cats are thus left handed, other are right handed!

Sex has no recognized effect on food perception in this species, even if feeding behavior can be indirectly affected by acute territorial competition in female cats, and by breeding season in male cats.

Breed may have some influence, although it is difficult to prove it unequivocally. It may be an area of future research.

Age affects ingestion behavior but less than in dogs *(Peachey & Harper, 2002)*.The increase of dietary experience and the decline of olfactory and gustatory capabilities may enhance fussiness or even provoke preference inversion.

► Environmental factors

> Social environment

The cat is a solitary hunter, but tends to gather in feeding and breeding spots in wild urban groups. The territory is transient and variable throughout time and space, i.e. it is possible that the territory overlaps between two cats but at different moments. Hierarchy in cats depends on the place and time during the day: it is a relative dominance. Territory may easily trigger aggressiveness and fights.

In collective housing, it appears that some competition may occur. Fights are somewhat rare if food is available in large quantities.

Unlike dogs **(Table 1)**, household cats do not appear to show social facilitation of eating: they usually eat alone and do not seem to be affected by the presence of another cat *(Houpt, 2005)*. Some cats will even share the bowl with another cat, while others may sit calmly and wait for their turn. A female in estrus can have the right to get food first. However, other researchers feel that cats show hierarchical issues regarding the food bowl with higher ranking cats displacing lower ranking cats from the food source in a multi-cat home *(Knowles et al, 2004)*. In ad libitum experimental situations, social feeding (as defined by time overlap of at least one minute between meals), occurs in duo with only 20% of meals *(Mugford, 1977)*.

For owners of cats living outdoor, feeding is a privileged moment for contacts. Quite often, the feeder has better or, at least, the easier

TABLE 1 - THE MAIN DIFFERENCES BETWEEN FELINE AND CANINE FEEDING BEHAVIOR

Cat	Dog
Strict carnivore	Omnivore
12 to 20 meals/day	1 to 3 meals/day
Feed during day and night	Feed during daylight
Regular eaters	Glutton feeders
No social value of the meal	Social value of the meal


© Yves Lanceau/RC/European cats

relationship with the cat. *Geering* (1989) has shown that the act of feeding is necessary to reinforce the bond, but is not sufficient to keep it. Other interactions, like petting, grooming, playing, talking, are required to maintain a newly established link *(Bateson & Turner, 1989)*.

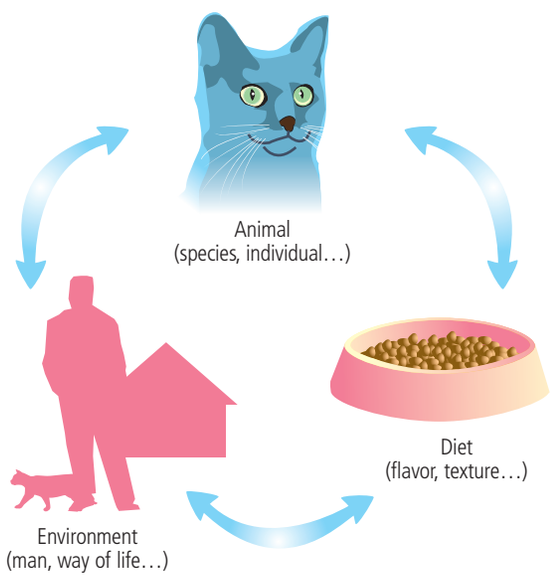
In the household environment, the rhythm of the supply of food often reflects the owner's lifestyle. Two or three meals are often fed during the day: in the morning before going to work, at the evening when returning, or even just before going to bed to keep the cat quiet!

Diet acceptance is largely influenced by the psychological, affective and material environment **(Figure 4)**. *Wolter* (1982) mentions various factors likely to influence the feeding behavior of the cat: tension between family members, change of light, sudden noise from stereo systems, different odors of cleaning product for the bowl, arrival of strangers, etc. This has nothing to do with food quality but an involuntary cat disturbance. Checking the feeding behavior during a recovery phase can lead to food refusal or lower acceptance. This situation is also observed when the owner has just bought a new food (new brand or new claim) and wants to check whether or not the animal accepts it. A very first analysis of perceived anorexia should review these unexpected but simple reasons! This disorder will be reviewed in the final section.

> Physical environment

Cats need to feel safe and secure within their home environment. To this end owners need to provide facilities for the main behavioral functions of eating, sleeping and playing and also ensure that the cat has the ability to control its own stress through the natural mechanisms of hiding and retreating. In tidy homes or those with built in furniture, places for cats to hide may be in short supply. This may create a situation where a cat might feel insecure and vulnerable without any escape routes or hiding places. Taking steps to provide the cat with a constant and predictable environment, both in terms of physical structure and scent profiles, will help to increase the cat's security; while the provision of access to high up resting platforms, secure bolt holes and hideaways may decrease the use of oral appeasing behaviors, such as over grooming and over eating. If all of the furniture in the house is built in it may be necessary to put up shelves for the cat to rest on, or clear out part of a cupboard or wardrobe to offer a safe hideout *(Dehasse et al, 1993)*.

FIGURE 4 - FACTORS CONTRIBUTING TO DIET ACCEPTANCE



► Influence of the food itself on feeding behavior

In the testing done on food choices and taste reactivity in cats *(Van den Bos et al, 2000)* two response sequences were noted and correlated to possible palatability reactions. A preference to consume an offered food was often preceded by a lick or a sniff of the feeding bowl, lip lick and face groom. Cats presented with food that was less desirable would lick or sniff the food and lick their nose. Whether the food was eaten was also partially dependent on the degree of hunger. In general cats will eat more of a desirable food regardless of hunger, but consumption of a less desirable food is often dependent on the hunger status of the cat.

Once a meal is consumed most cats will groom themselves regardless of perceived palatability. As direct gastric canulation leads to the same post-prandial behavior (without soiling lips and cheek), it is considered as an innate neurophysiologic reflex.

One of the most important features to consider is that cats will often eat and prefer a novel diet over a familiar one. The intensity of **neophilic behavior** depends on the foods' relative palatability and on the duration of exposure to the usual food. If the new food is less palatable than the usual food, the effect is shortlived. Twenty four kittens received the same food for 16 weeks, and then underwent a comparative test [two bowl test] for several days with the usual food and a new food of equivalent palatability. The first day, the kittens systematically chose the new food. After the second day, the difference was no longer significant between the two foods *(Mugford, 1977)*. The novelty effect lasted only a few days (rarely more than 5 or 6 days), after which dietary preference stabilized.

Neophilia is preference for a food never encountered by the animal or food that has not been recently encountered by the animal. This behavior is quite common in carnivores and has been identified in both dogs and cats. Neophilia enables animals to diversify their diet and achieve a better nutritional balance.

In the home, the preference for frequently changing the diet, a ritual that many owners participate in, is called **metaphilia** (from the greek, meta: "transformation"). This corresponds to an increase in consumption due to the renewal and alternation of known diets *(Rabot, 1994)*. This is clearly observable in the cafeteria regimen in practice. This behavioral trait has led some manufacturers to create packaging of multi-single portions containing various varieties.

When changing a pet's diet, one must be prepared for the possibility of neophilia and the associated increase in energy consumption during the first month after the new diet is introduced. The novelty effect is accompanied by temporary caloric overfeeding. In the first month, cats may eat up to100 kcal/kg. The effect then wanes and consumption stabilizes around 60 kcal/kg after two months *(Nguyen et al, 1999)*. Whenever a change is made to a pet's diet, owners should take care to measure out the food to ensure proper caloric delivery.

Breaking this natural neophilic trend, an owner can choose to always give the same diet. There is a risk of boredom with a perceived decrease in palatability (even it the food is complete and well balanced). One may relate that phenomenon to the human concept of "oral satiation" (always eating chocolate or eating oysters too often may decrease their palatability). On the other hand, choosing to frequently vary the diets beyond the carnivorous status of cats and to consider them as omnivorous by humanization, may lead to **neophobia** and again food refusal.

Some specific events can trigger fixation to one food and acquired **food aversion**. These disorders will be discussed below.

2 - Description of the feeding behavior of the cat

► Predation and hunting

Unlike the domestic dog, the body type of the domestic cat is not far from its wild ancestors. However, differences in prey sizes have led to significant differences, e.g: domestic cats use their incisors less, meals are more frequent and their way of consuming prey is also different: domestic cats begin with the head, large felids begin with the viscera.

> Hunting instinct or learned behavior?

Predatory behavior is innate: all cats probably know how to hunt, but certain aspects seem to be learned. Approach and pursuit are stimulated by littermates. Hunting behavior is more likely seen in kittens from a queen that hunts. Kittens learn to catch and to kill the same prey that their mother hunts *(Bateson & Bateson, 2002)*.

During weaning, there is an amazing training program for hunting displayed by the queen:

- 4th week: the queen brings meat pieces to the kittens
- 5th week: she eats dead prey in front of her kittens
- 6th or 7th week: she lets them eat the prey
- 8th week: she brings a live prey in order for the young hunters to learn to kill.

The first hunting sessions occur at 3 months. At 4 months of age, the young hunters are confirmed. The absence of predatory experience does not seem to interfere with motor abilities but often reveals prey selectivity issues. A kitten must indeed be taught that a mouse can be eaten. If it is not done before the age of 3 months old, the cat can starve even in the presence of the unknown prey! However, even cats that did not have access to prey when they were kittens can learn to become proficient hunters.

It has been speculated that feeding a cat may reduce its desire to hunt, but evidence to support this is lacking or controversial. Cats that are provisioned with food at home spend less time hunting than cats that are not provisioned with food, but both still hunt even if the number of actual prey caught and consumed is hard to quantify *(Fitzgerald & Turner, 2000)*.

Hunting session

Unlike dogs who hunt in packs, cats in the wild are solitary and opportunistic hunters. They catch small prey and eat alone. Observations show that they often fail in their attempts to catch prey: only 13% of tracked prey is actually caught *(Kays & DeWan, 2004)*, every success representing 3-5 attempts *(Fitzgerald & Turner, 2000)*. A cat brings home an average 0.7 prey a week *(Woods et al, 2003)*.

Hunting sessions can last 30 minutes, on distances between 600 and 1800 m in their territory. An obvious variability exists between individuals: for example, male cats hunt longer and further than female cats.

Cats spend two-thirds of their awake time to hunt in natural conditions. Hunting behavior is composed of several sequences:
- stalking the prey
- approaching and pursuing
- catching the prey by a central leap (their body will be low to the ground and they move slowly toward the prey, pausing prior to leaping to attack)
- killing by biting the neck, following an eventual fight
- consumption rarely occurs at the location of the catch (for the reason of quietness).

The domestic cat is a member of the Felidae family, Felis catus *and is a strict carnivore.*

© J.-P. Lenafant/RC/Norwegian Forest Cat

As the process progresses, the sequences are less and less modifiable by the cat's experience or it's' environment. The first steps (seeking, stalking and approach) are indeed flexible as a result of adaptation to different situations, while the last ones (e.g. attack and bite) are more stereotyped to secure efficient catch and kill, and thus individual survival.

Cats rarely bury their catch for postponed consumption. Cats eat rather quickly and then regurgitate furs and bones. Prey cleaning is rather poor, unless it is voluminous (such as pigeons or young rabbits). The cat breaks the bones and masticates with its large premolars. It can eat an entire mouse in less than one minute. When consuming a mouse, it starts at the head and eats

in the direction of the tail *(Case, 2003)*. It is often the logical consequence of the killing method, during which the neck is broken. It might also be related to an adaptative behavior, securing prey catch and intake.

Leyhausen (1979) (quoted by *Rabot*, 1994) has shown that the complete hunting sequence is in fact controlled by a system of progressive and different motivation phases:

- interest is awaken by auditory stimuli (scratching, grating), which enables the cat to locate precisely the prey. In veterinary practice, scratching the consultation table is indeed often the best way to draw attention from the cat;
- visualization of rapid movement triggers approach. Experience nevertheless allows the cat to recognize a motionless prey and to attack it;
- catch answers to more precise visual and olfactory clues and is triggered by tactile stimuli.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Feral cats hunt every 2 or 3 days, whereas domestic cats can hunt everyday.

Leyhausen's studies seemed to indicate that prey capture, killing and consumption were indeed independent actions. Capture and killing appeared to be also independent of hunger but if hunger pre-exists, predatory sequence is complete as hunger is the only reason that explains consumption.

Each stage induces in turn the following one, which permits the succession of all sequences by different stimuli. Hunger is not compulsory to trigger prey seeking but increases kill probability. Satiety does not inhibit sacrifice.

The domestic cat hunts quite often but rarely eats the prey. The system of independent phases proposed by Leyhausen would indeed explain that cats just fed can display all sequences without food intake. Some steps can be repeated and the owner can attend a cruel predatory play, during which prey is still alive while being handled in all ways. The fact of bringing back the prey to the owner can be falsely interpreted as a proof of the maternal like type of bond.

> The most common types of prey

Each catch represents only a small percentage of the cat's daily energy requirements (the caloric content of a mouse can be estimated at 30 kcal). It is possible to find up to 12 small preys in a feral cat's stomach. This represents an adaptative behavior to scarcity periods. Continental cats essentially hunt young lagomorphs and rodents. Birds come after in the list and reptiles even lower. Cats living on islands depend mainly on rats, mice and sea birds.

Cats are versatile and generalist hunters. They can easily move from one prey type to another depending upon ecological evolutions. They can even go to some domestic feeding during scarcity periods. On some islands, feline predation has been put as the cause of some species extinction, according to *Bateson and Turner* (1989). Studies focused on the effect of predation on wildlife are however limited and it is unclear whether the extrapolation of these data to the global feline population is accurate.

> Techniques to limit predatory behavior in domestic cats

Attempting to decrease predation by house hold cats is probably a worthy goal. Predatory behavior is a normal behavioral pattern in cats but often distressing to their owners. Although 6 of 10

cats (in the United States) and most pure breed cats are kept indoors and therefore cannot hunt, in Europe many cats (7 of 10) have an outdoor access so they can hunt and kill small rodents and birds. Owners often find this behavior objectionable especially when cats direct the behavior toward song birds and/or bring prey home.

Predatory behavior is best prevented by keeping cats indoors and obtaining kittens from queens that do not hunt (so as to get inexperienced individuals). In addition, keeping a quick release cat collar with a large bell on the cat may diminish their proficiency. *Nelson et al* (2005) compared collar mounted warning devices on reducing predation in cats in the UK and found that there was no significant difference in the prey return rate between cats wearing collars with one bell, two bells or a sonic device.

The cat has been domesticated for nearly 6000 years but has not lost his exceptional hunting skills thanks to the independency of predatory sequences. Cats can easily return to the wild and survive without human intervention.

► Domestic feeding

Cats spend from 1 to 2% of their awake time eating. When feeding a household cat, the food can be provided either in a controlled manner i.e. as meal feeding or as free choice feeding. Regardless of the type of feeding regime chosen, it is useful to establish regular feeding and eating patterns for house hold cats **(Table 2)**.

> The place of the feeding bowl

The territorial organization of the cat's life must be taken into consideration. Each spot has a defined dedication for the cat: feeding, resting, playing, eliminating. And these functions are not mixed. You would not eat in the middle of the train entrance or in your toilets. It is the same for a cat! **(Figure 5)**.

Bowls have to be small, to control intake and to encourage frequent refilling. Regular cleaning of the bowl is necessary, to avoid off smells and safety issues. In homes with multiple cats, each cat should be offered their own food bowl. Antagonistic interactions between cats may restrict some individuals from access to food and water bowls leading to weight loss and perhaps medical complications. In addition, because cats may not share space equally, food bowls should be allocated through out the environment, not all in one location. Care should be exercised to note where individual cats spend most of their time and place food and water bowls in those locations. Litter boxes should be placed at a significant distance from the feeding location.

Table 2 - Feeding regimes in house hold cats

Method	Advantages	Disadvantages
Meal feeding The owner controls either the time the food is provided and/or the amount of food provided daily. Usually the cat is provided with 2-3 small meals daily at set times.	- Allows the owner to monitor food intake - Helps assess health - Allows all cats access to food - Increases bonding time	- Some cats may solicit food at other times - May not meet the cats internal schedule for eating
Free choice feeding The cat is provided with food at all times.	- Allows the cat to control consumption - The cat can eat multiple small meals daily	- Unable to monitor intake - May lead to over consumption and obesity - Allows no time for human-animal bonding
Combination feeding Free choice dry food, meal feeding wet food once or twice daily.	- Allows multiple small meals daily - Allows for bonding time	- Unless closely regulated over consumption can occur - Some individuals may not get enough to eat

> Meal feeding

When pet owners use a meal feeding method to feed their cats they either control the time the food is provided or the portion size provided. It is the best method for canned food so as to secure freshness and safety. Leaving leftovers for hours in the bowl indeed leads to bacteriological risks and palatability decrease due to organoleptic deterioration. Manufacturers have understood this problem and now propose single portions diets. Because cats eat multiple small meals when hunting, most household cats find

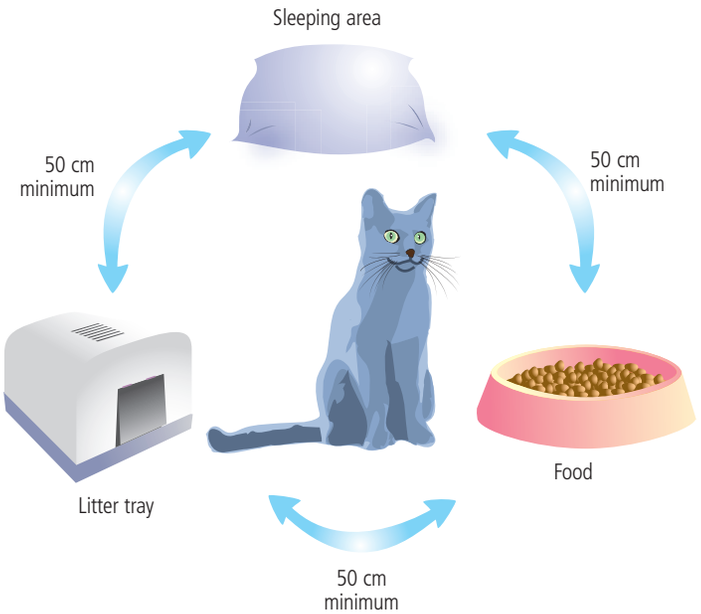
single meal feeding unsatisfactory if it is the only method chosen. If an owner chooses to feed its cat in a time controlled manner, at least two meals per day should be provided. However, an increased frequency of meals may help control hunger and decrease excessive food soliciting behavior. It is indeed amazing to see cats learning to detect when they can get extra food. They associate some events to a high probability to get reward e.g. during the advertising break of the evening TV movie or when the owner puts the kitchen in order (they can be warned by the noise of plates in the dishwashing machine!).

Meal feeding methods

- With **time controlled feeding**, the food is left available for a set amount of time and then picked up and not provided again until the next feeding time. For most cats, 30-60 minutes should be allotted for eating when fed in a time controlled manner *(Case, 2003)*.

- With **portion controlled feeding**, the amount of food provided is measured and placed in the bowl and once it is consumed, no more food is provided until the next meal. For a single household cat, portion control can help control weight while potentially allowing the cat to eat several meals through out the day, something that cannot occur with timed feeding.

FIGURE 5 - THE MINIMAL DISTANCE BETWEEN THE FEEDING PLACE AND THE ELIMINATION AND RESTING PLACES



The feeding station must be in a quiet place (not close to the washing machine), at the right distance from the litter box.

Meal feeding in either manner has several advantages. It allows owners to determine how much food the cat consumes in a 24 hour period. Food consumption is often a good marker of health and knowing how much the cat eats can help an owner determine how the cat feels. If multiple cats reside in the home it may allow the caregivers to assess each cats eating pattern and access to food and may help the owner to recognize health or social problems in the cats. Meal feeding also allows the pet and the owner to interact several times a day strengthening the human-animal bond.

Free choice feeding

In free choice feeding food is provided to the cat at all times so that the cat can eat multiple small meals in a 24 hour period. Domestic cats often eat multiple small meals through out the day. Depending upon observations, this number varies from 8 to 16. This is linked to the evolution of the cat to an opportunistic feeding pattern, nibbling small amounts of food on numerous occasions. This method relies on the cat ability to self regulate intake. This is the best option when the cat is fed with dry food. However, due to the increased palatability of commercial cat foods coupled with reduced exercise, cats may over eat and become obese. In addition, self feeding does not necessarily allow the human caregiver to determine daily intake especially in homes with multiple cats. With self feeding, a change in food consumption and resultant weight loss may not be noticed for some time perhaps imperiling pet health. Self feeding also limits the pet-owner interaction around feeding time.

Some pet owners may combine meal feeding and free choice feeding by providing set meals of small amounts of wet food and provide dry food in free choice. It creates a social re-enforcement of food intake, although this effect is much less important than in dogs. The cat is invited to eat wet food as a "plus" and the calorie content is added to the normal dry food ration spread over the day. In some cases the energy balance can be excessive. The practitioner must keep in mind that some cats may have difficulties to regulate their energy consumption when fed two different

types of food: a strict control of the quantities fed to the cat and of the nutritional balance of both types of foods is highly recommended.

> The role of the human in feline feeding

Because most household cats do not hunt to meet their nutritional needs, when they are hungry they target their pre-meal behaviors and food soliciting behaviors towards the humans within the home. These behaviors include vocalization, rubbing on nearby objects and on the humans. Often if the person moves in the direction of where the food is provided or stored, the cat may run in that direction or continue to wind between the legs actually impeding progress. It has been suggested that people who feed the cat have a better relationship with the cat perhaps because of these opportunities to interact *(Geering, 1989)*.

Owners often inadvertently assume all vocalization and attention is in fact a food soliciting behavior. They then respond by feeding the cat, resulting in a potent learning process. The owner's response is acting as a reward for vocalization and attention seeking behaviors which usually will increase in frequency and intensity. Not only can these behaviors be distressing to the owner, excessive food intake will also lead to obesity and related medical problems. Owners should learn to recognize when enough food has been provided and consumed, and not reward these behaviors with food. They then should find an alternate activity such as play or grooming once the nutritional needs have been met.

> Observations of feeding behavior: how the cat eats

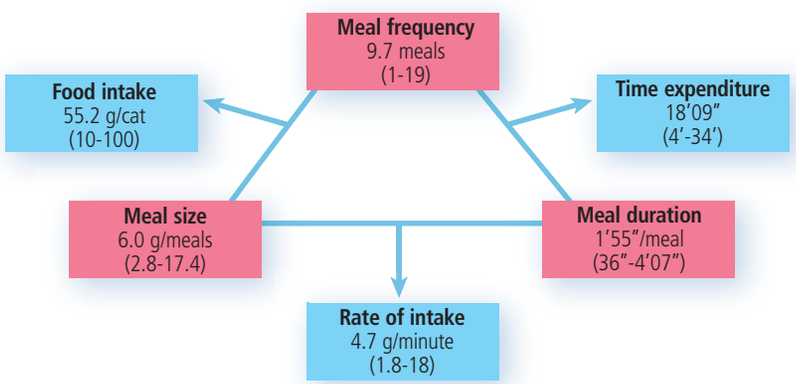
Many nutritional studies are based on the study of the factors affecting the amount of food that cats ingest. The regulation of ingestion is a complex and still poorly understood phenomenon. The frequency and size of meals represent two key parameters of feeding behavior.

Number of meals per day

Each cat has its own way to dispatch its meals throughout the day. A cat generally needs 3 weeks to get a stable life pattern. In an ad libitum situation, it ranges from 3 to 20 meals per day *(Kane et al, 1981; Houpt, 2005)*, like water intake *(Mac Donald et al, 1984)*. In cattery conditions, when cats are fed ad libitum with dry food, the dietary consumption is influenced by the night and day alternance: the dietary consumption at night is often inferior to consumption during the day, but during the night, the meals are larger and longer *(Kanes et al, 1981; Royal Canin Research Center: internal data, 2004)*.

FIGURE 6 - THE FEEDING PATTERN OF THE CAT OVER 24 HOUR

(Source: Royal Canin Research Center; internal data, 2004)



The feeding behavior of cats living together in groups was followed using an electronic scale with access controlled by an electronic chip. This system makes it possible to follow in real time each cat's consumption profile in terms of the number of meals, the meal size and the duration of the meal (between brackets: mean-extremes).
Data were collected with 8 adult domestic cats (2 to 3 years old), fed ad libitum with the same dry food over 17 days.

Meal size, meal duration and speed of eating

Meal size increases with palatability (especially the first meal) or when the feeder goes from meal feeding to ad libitum feeding. The average duration of a meal is almost 2 minutes **(Figure 6)**. The speed of eating is an important criterion for the owner's perception. It is in fact much more influenced by food structure than palatability. For dry kibbles, the eating rate increases from 2 to 4 grams per minute. For canned product, it lies between 4 and 8 grams per minute.

Studies done at the Royal Canin Research Center illustrate how the number of meals, quantity of ingested food

and the speed of ingestion are significantly different for different breeds in exactly the same environmental conditions and sharing the same nutritional history **(Table 3)**. The frequency of the meals is the most variable parameter between the different breeds studied with Bengal cats showing the highest frequency. Maine Coon cats tend to take the largest meals and Persian cats the smallest. Persian cats spend twice as much time per meal compare to the average of the other breeds studied (3'27" vs 1'49") *(Royal Canin Research Center: internal data, 2004)*.

TABLE 3 - FEEDING PATTERN DIFFERENCES BETWEEN PURE-BREED CATS AND DOMESTIC SHORT HAIR CATS
(Royal Canin Research Center: internal data)

Breed	Intake	Meal frequency	Meal size	Meal duration
Bengal	+	+	=	=
Maine Coon	+	+	+	=
Siamese	+	+	=	=
Persian	=	+	-	++
Birman	=	=	=	=

+ Statistically higher in purebreed cats compared to domestic short hair cats
– Statistically lower
= No significant difference ($p > 0.05$)

A group of 68 cats of different ages and breeds (European cats: 30; Persian/Exotic Shorthair: 8; Siamese/oriental cats: 8; Maine Coon: 9; Bengal: 7; Birman: 6) with free access to food for 18 hours were evaluated over an 8 day period. There was an average of 12.2 meals, with an average meal size of 5.3g/meal. On average, the cats ate 59.7g/cat/day and spent 23 minutes eating. These results mask great disparities between breeds.

Types of prehension

Prehension of food explains the apparent eating rate of cats. The cat has a small mouth and small teeth which are better suited to holding and killing prey rather than grinding and chewing food *(Case, 2003)*. The initial role of the canine teeth is to seize prey whereas the carnassials tear flesh.

Innovative studies conducted by Royal Canin in collaboration with the *École Nationale Supérieure des Arts et Métiers* (ENSAM) in France, demonstrated that cats exhibit three distinct methods of dry food prehension. The most common method is called labial prehension and involves the grasping of kibble using the incisors, without the use of the tongue. The second method is called supralingual prehension, which involves the cat using the dorsal side of the tongue to "lap up" their food. The third method is called sublingual prehension, in which the cat applies the ventral side of the tongue to the kibble, then turning it backwards **(Figure 7)**.

FIGURE 7 – PREHENSION MODES IN CATS

Supralingual mode | Sublingual mode | Labial mode

By filming cats from below as they eat on glass surfaces, Royal Canin has discovered that certain breeds of cats are more likely to demonstrate one type of prehension style over another. For example, brachycephalic breeds such as the Persian, have difficulty picking up kibble with their teeth, because of the structure of their head and jaw. In 80% of cases, Persians use their tongue to pick up a kibble rather than their lips or teeth.
Mastication is somewhat poor in cats. Jaw joint configuration allows only vertical movement. They often break the kibble in one strike, or even immediately swallow in one gulp! This occurs commonly in cats with dental pain, who avoid breaking the kibbles with their teeth, rather they swallow the kibble whole and even vomiting quickly after.

The role of the tongue is very important when speaking about canned food. It acts like a spoon. Its rugose surface easily catches pieces of loaf or chunks.

Each of these parameters must be considered when feeding cats and creating environments conducive to good eating habits.

3 - Determinism and regulation of food consumption

► External stimuli: picking the appropriate food

Cats appear to be sensitive to the odor, form, texture and palatability of their diet (Table 4).

> Odor

Odor is key for cats: an off flavor arising from rancidity of fat can halt food intake regardless of the taste or nutritional value of the food. Odor is the major criteria of food selection. Experiments that alternated odor flow across the bowl of kibble have shown an increased numbers of meals and food consumption during the odor circulation phase.

Cats prefer food that is at room temperature or near body temperature (38 to 40°C), most probably because it contributes to volatilization of food odors. Temperature interferes with odor for volatilization of compounds. It is also something closer to prey temperature. In practice, increasing food temperature from 20 to 40°C can enhance food consumption up to 80%.

Prehension and mastication in the mouth leads to food re-warming. This can be important to get an improved perception of odors through retronasal olfaction.

> Shape

Since prehension occurs before food enters the cat's mouth, the ease of prehension is important to consider (see trials with Persians). For kibbles, shape determines the lines of breakage and convenience to guide toward the ancestral carnivorous drive, where it is broken in one strike before swallowing. Shape, by determining surface to volume ratio, also displays more or less flavors.

Table 4 – The successive steps of food consumption by the cat

Phases	Sense use	Characteristics of the food tested on the cat	Advancement paths to improve the palatability of the food
 **1 Selection**	Smell	Smell	Choice and quality of the ingredients, aromas and fats in the coating
 **2 Prehension**	Touch	Size, shape, texture	Technological process: grinding, cooking, drying
 **3 Chewing**	Taste	Taste	Quality of ingredients
 **4 Digestion**	Physiological reactions	Food security	Nutritional quality of the end product

> Texture

Some research has suggested differences in food preferences between domestic pet cats and free-ranging cats living on farms (*Bradshaw et al, 2000*). Farm cats preferred raw meat diets while house cats preferred harder or drier types of food (e.g. kibbles). These data may reflect learned preferences and/or neophobia of a food choice that is provided infrequently as was the raw meat to house cats. Cats used to a certain texture or shape of dry kibble may refuse new diets that vary in either one of these dimensions.

The food most frequently offered to cats comes primarily in two forms, dry cat food and moist (canned or pouch) cat food. Cats like the "cracking texture" of dry kibbles and the high moisture content (75- 80%) of canned food however, rehydration of dry food is not appreciated by cats, unlike dogs.

Dry cat food has certain advantages for the human caregiver:

- it is easier to store, to keep for a longer period of time
- it can easily be fed free choice without concerns of spoilage
- it may offer dental hygiene properties. The chewing and grinding may help prevent plaque and calculus development (see chapter 10) and dry diets have been specifically formulated to increase their dental cleaning properties.

Some cats show a preference for certain shaped kibble morsels and have preferences for mouth feel and surface to volume ratio of the food *(Crane et al, 2000)*. Cats reject broken kibbles.

© Royal Canin

The texturometer is used to measure the kibble's resistance to the force of the cat's teeth and jaws. Interchangeable modules imitate the shape and size of teeth according to the size and age of the cat.

Canned cat food can either be a complete and balanced diet or just a supplement that is primarily meat. Canned foods are blended and contain additional water; in some cases the moisture of the product reaches 85%. It can result in a low caloric density and thus promote higher intake on a long term basis Many cats find canned foods extremely palatable due to the high water, fat and protein content *(Case, 2003)*. Product texture is very important to determine eating patterns:

Minced products are continuously swallowed, the cat staying crouched and never lifting its head. The speed of eating is high and owners may perceive that this is a reflection of palatability, whereas the reason is more mechanical than sensorial!
Jelly products lead cats to take large gulps of meat. They have to chew a bit and lift their head simply to swallow. Some owners may have the perception that their cat is more reluctant to eat. Others may feel that the cat is appreciating the food, tasting it quietly, thanking them by looking at them and licking their lips!

Semi moist foods: most of these products are marketed as treats for cats and are not meant to be used as the sole dietary source of nutrition. They are softer in texture than dry food, but they are not as moist as canned food. They do not require refrigeration and have long shelf lives. Some ingredients, used as preservatives of the water level, may even negatively affect palatability.

Homemade diets are not usually recommended since cats have specific dietary requirements that may be hard to meet.

> Taste and the composition of the food

Food palatability is the very first key factor of success for petfood acceptance, for both cats and owners. Despite a lot of publications concerning feline food preferences or aversions, cat's preferences are more nutrient-orientated than ingredient-orientated. Quality and freshness of raw materials are nevertheless important.

An important technological know how (enzymatic hydrolysis, fermentation, etc.) has been developed, leading to the commercialization of very efficient natural flavors, homogeneously coated onto the kibbles in order to drastically increase their acceptance **(Figure 8)**. However, there is little information that the authors can provide in this text as the data remains strictly confidential among palatability experts in petfood companies.

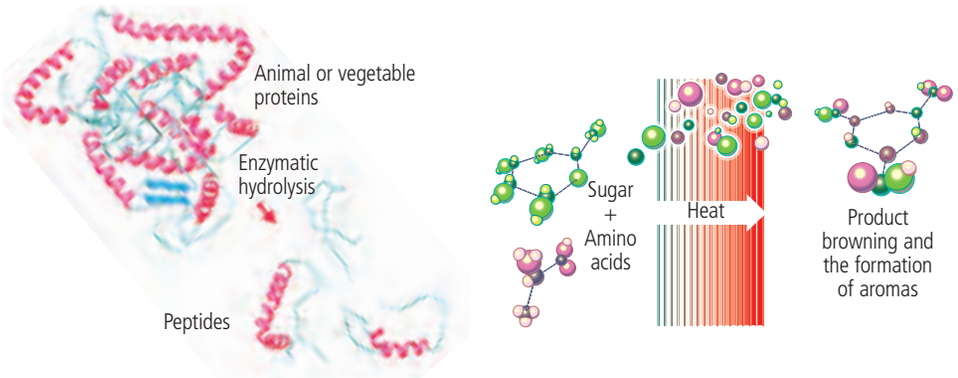
Proteins (especially hydrolysed proteins from meats, and sometimes plants such as soyabean) as well as fat are both palatable for cats. Some ingredients like yeasts and specific acids are also appreciated by cats.

The selection of fat is important, and above all their protection against oxidation. Fat can also interfere with palatability through some texture effects. Short and medium chain fatty acids (caprylic acid, coconut oil, etc.) are sometimes associated with altering the palatability of the food

FIGURE 8 – MAIN TECHNOLOGIES USED IN THE DEVELOPMENT OF AROMAS

1. Hydrolysates are often obtained from heated, acidified poultry proteins. Enzymes are used to breakdown protein into palatable compounds.

2. Maillard reactions are used to aromatize various products (coffee, biscuits, roasted meats, etc)



(Mac Donald et al, 1985) but this effect can be hidden when the ingredients and the surrounding formula are appealing for the cat.

Palatability has too often been blamed for feline obesity. However, the food's energy concentration is more important than palatability. An inactive, neutered cat that has access to food with a high-energy concentration will inexorably gain weight. Prevention is about maximizing activity and optimizing the composition of the food.

A cat has more difficulty limiting its food consumption if the kibbles are very rich in fat. Cats fed ad libitum with a food containing 20% fat develop greater adipose reserves than when the fat level is halved, regardless of the animal's sex: male or female, intact or neutered *(Nguyen et al, 1999)*.

► Elements of the regulation of hunger

Global palatability of the food is crucial, but hunger is a sine qua non condition for the cat to eat.

> General principles

Energy supply is controlled by homeostatic regulatory processes for food intake and body expenditure or both. Nutrient supply to the body must be constant. However, food intake is a discontinued and periodic behavior. A medium and long term regulation system thus exists; with the involvement of body storages (essentially fat). Everything is done homeostatically to prevent loss of tissues and weight loss.

Controls of food intake can be classified by several pathways:
- **behavioral pathways**: habits and learning such as sensorial or metabolic conditioning
- **nervous pathways**: mastication effecting oral satiation, stomach filling effecting physical satiation
- **metabolic pathways**: short term glucostatic theory, long term lipostatic theory

Glucostatic theory in cats

A low level of glucose in the hypothalamic cells triggers hunger *(Rowland, 1985)*.

Lipostatic theory

The endocrine role of adipose cells has been studied during the past few years. Many cytokines have been identified that act on insulin metabolism, inflammation, etc. Among these, leptin, the satiety hormone discovered in 1994, has been clearly involved in appetite regulation *(Bouret et al, 2004)* however, there are few studies in cats.

One satiation signal cannot act alone to control body balance which is the result of a series of separated control points, acting on a different time scale. Animals control their food consumption through 3 major food compounds:
- water
- sodium (all other mineral are consumed in relation to caloric density)
- energetic nutrients

If formulation is correctly done and if the feeding distribution well adapted to behavior requirements, energetic regulation is then efficient.

It has been suggested that the sensorial properties of a food become more important than metabolic ones for deprived cats. This could be an adaptative protective behavior during which cats seeking desperately for food become more discriminating to avoid poisoning risks in excessive hunger states. For well-fed cats, both palatability and nutritional values are acting in the regulation process.

From a practical standpoint, the only valid clue of efficient regulation is the stability of body weight. Significant inter-individual variability does exist. When analyzing publications and the possibly contradictory conclusions, it is important to perform a critical evaluation of what kind of regulatory processes are explored in relation to the beginning (animal reaction), the duration (constant modification) and termination (new equilibrium status).

> Energy regulation

Many experiments on caloric dilution of food content have been performed. Some contradictory conclusions have been drawn, that are often linked to the methodology employed (e.g. the addition of cellulose, water, clay etc).

Under very stable conditions, the cat seems able to control its food intake in relation to caloric density (more precisely in relation to dry matter caloric density). This process starts within 2 to 3 days and requires at least 3 or 4 weeks *(Rowland, 1981)*. Meal size is most affected, secondarily meal frequency. However cafeteria feeding (i.e. changing and varying daily dry matter content and palatability) disturbs this natural ability. This is typically what happens in the home when the owner frequently alternates canned and dry foods, brands, varieties, etc.

> Protein regulation

In cats, contrary to humans or dogs, protein has been shown to increase food intake *(Servet et al, 2008)*. Therefore, limiting the amount of protein (with a fiber substitution) is an original strate-

Why do some cats like fish so much?

In its original environment – the cat is adapted to deserts – where there is limited availability of fish. So where does this attraction for fish flesh come from - even to the extent that certain cats take great delight in raiding garden ponds, and feasting on gold fish and young koi?

Fish is a source of protein. Historically, cats have always been very opportunistic and quickly realized that there was obvious benefit in hanging around the quays when fishing boats returned to port because they could eat the remains from cleaning and gutting of the fish. In the time of sailing boats, voyages took a long time and boats took on board provisions of cereals - unfortunately accompanied by mice and rats that fed on them. Cats were therefore taken on board as well in order to control the population of these undesirable rodents and, once their mission was accomplished, the sailors would therefore show their gratitude by giving them fish.

In Asia, similar to human food, ocean-products are very commonly used in catfood.

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gy to limit spontaneous food/energy intake. These observations might be useful in the design of a diet to manage feline obesity (see chapter 1).

It has been suggested that some specific amino acids, such as tryptophan can affect general behavior (agression, excitability or territoriality modulation) in dogs *(Bosch et al, 2007)*. There may be a relationship between tryptophan intake by the brain and the level of carbohydrate in the diet. However, changes of the level of carbohydrate in the diet are often linked to concommittant change in the protein level, which can also affect behavior. The mechanism how the intake of nutrients that act as precursors of neurotransmittors (choline for acetylcholine, tyrosine for catecholamines, and tryptophan for serotonin) effect food composition is unclear and obviously needs more scientific work.

> Physical satiety

It has been proposed that the receptors for physical satiety in cats may be more efficient in regulating food intake than the energy pathways. In the single meal feeding situation, the cat is able to achieve its daily needs, even within 5 days following a transition from ad libitum to one hour distribution *(Thorne, 1982; Finco et al, 1986)*.

Ranking of control pathways is logically linked to the action level: physical satiation in the short term and caloric satiation in the medium term. The link is the fact that dry matter is both responsible for filling the stomach and for providing energy.

From a developmental standpoint, experiments on new born kittens *(Hinde, 1975)* would suggest that oral satiation is acting first before the development of gastric satiation: in other words, milk intake is less important than suckling movements.

Sleep is increased after meals. The effect is noticeable 3 hours after intake. Latency is variable: the quicker it appears, the longer it lasts. It is medidated by endocrine pathways and depends upon nutrients, duodenum pH, and gastric emptying.

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Nepeta cataria *(catnip plant)*
The catnip plant is usually well appreciated by cats. It is a generic name that applies to various plants sold for cats.

4 - Disorders of ingestion behavior

In the owner's mind, feeding behavior is associated with health, well being and pleasure, especially in mature markets where anthropomorphism is strongly present. This is probably why so many clients regularly question veterinarians about the relationship of food intake to some disturbances.

We will distinguish qualitative troubles (plant eating, pica and wool sucking, fixation on one food, learned aversion) from quantitative troubles (hyperorexia and anorexia).

► Qualitative disorders

> Grass and plant eating and catnip

Cats frequently eat grass if they have access to it and/or they may ingest house plants. Plant ingestion may be considered as a natural phenomenon which makes vomiting easier and thus the expulsion of hairballs. It becomes a behavioral issue when addiction occurs, i.e. if a cat systematically seeks a specific plant.

The **catnip plant** *(Nepeta cataria)* often induces a reaction in cats. Not all cats respond to catnip: 30-50% of cats do not respond at all and the response appears to be inherited and modified by both age and experience *(Beaver, 2003)*. When exposed to catnip a cat who responds will usually smell it, lick it, chew or eat it. The cat may hold the catnip in their paws if it is fresh. Cats will often roll in the plant. Some cats become quite animated and leap and play. The sequence is accompanied by head shaking, rubbing of the

cheek and chin against the plant and profusely salivating. This may be perceived by an unexperienced owner as an estrus-like behavior. The response lasts 5-15 minutes and cats may be refractory to catnip exposure for about an hour. This is a sort of satiation phase following the excitment. The active component, or at least the most powerful one, is a nepetalactone, a terpenoid with a special attraction effect to female cats *(Sakurai, 1988)*.

Valerian *(Valeriana officinalis)* produces similar effects to catnip. Cats roll on roots, urinate over it and exhibit signs of great excitement. After chewing the plant, the cat will roll for 10-15 minutes on the floor, rub against objects and exhibit estrus-like behavior.

Actinidia (including chinese gooseberry): when presented with this plant, the cat stops eating and even stops sexual activity. On detection of the smell, they will seek its origin and roll on their backs in a state of total ecstasy.

Olive wood
Most cats chew and lick olive wood objects and rub at them. Olive flesh is not attractive to cats, it is more the nut.

This attraction to plants may become annoying and more importantly, as many house plants are poisonous, can have serious consequences when ingested. In addition, most owners find the consumption of houseplants objectionable and punish the cat for doing so if they catch the cat in the act. This can often result in a cat that is frightened of the owners. Treatment aims at providing acceptable plant material for ingestion by creating a cat garden of grasses (sold in many petshops) and plants that are acceptable and safe for consumption by the cat. Other plants should be placed out of reach either high off the ground, secured in another room or outdoors. In some cases making the plants aversive using hot-pepper solutions sprayed on the leaves or a water sprayer if the cat gets too close diminishes the behavior.

> Pica and wool sucking / chewing behavior

Pica

Pica refers to the voluntary ingestion of non dietary, non nutritional items and can include clothing, electric cords, wool, fabric, cardboard, plastic and many other items. Some cats may actually ingest the items and intestinal blockage is possible.

It represents between 5 to 10% of behavioral problems in cats. Often pica occurs in young, active animals and in some cases a genetic predisposition is suspected but has not been proven *(Beaver, 2003)*. It is important to keep in mind that kittens actively explore orally their environment up to 6 weeks of age and voluntary intake of unedible items can occur without being pica. Beyond that, special attention is due.

The origin of pica is in fact not very well known. Some mineral or vitamins deficiencies had been incriminated in the past, but the tremendous formulation improvement of cat food has eliminated this possible theory. Massive parasitism may be a similar contributing factor in farm cats.

Medical conditions such as feline leukemia and feline immunodeficiency should be investigated since they may contribute to abnormal behaviors. In dogs, exocrine pancreatic insufficiency has been associated with pica, but that has not been noted in the cat *(De Braekeleer et al, 2000)*. In other situations a lack of an enriched environment, dental problems, teething, attractive odors on objects and attention seeking have all been considered as contributory factors for pica.

Pica is thought to first be exhibited in situations of conflict and/or anxiety for the pet. In cats the initial situations may be social situations between cats, changes in social interactions with family members, moving house, etc. Over time the problem behavior occurs in other situations and more frequently until it interferes with function. Diagnosis of a compulsive disorder is based on exclusion of other causes for the behavior.

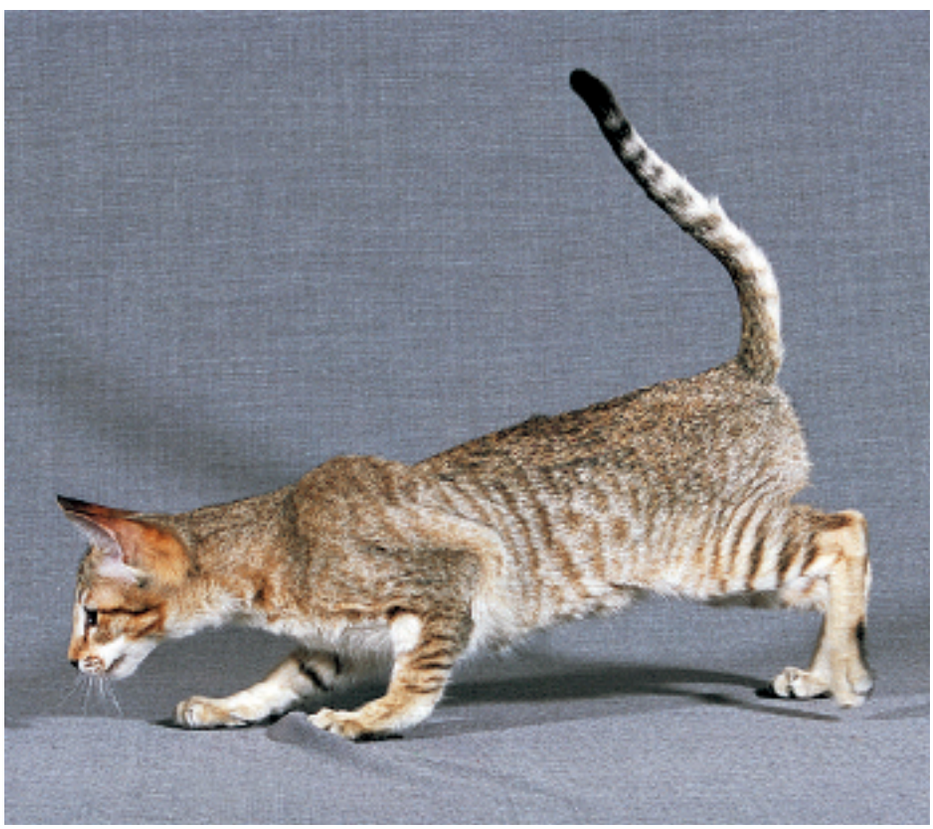
Wool sucking

Wool sucking has to be distinguished from true pica. This behavior is considered to be a compulsive disorder *(Luescher, 2002)*. Wool sucking occurs when a cat takes clothing items, usually woolens (but other fabrics may be chosen) and sucks or chews. Some kittens are naturally sucking their littermates or their own skin: later, this habit can extend to other species, cushions, or the owner's clothes. Under natural conditions, kittens can suckle their mother up to 6 months of age. In domestic conditions, weaning is earlier (6 to 8 weeks). *Houpt* (1982) hypothesized that it was the result of a suckling deprivation as a consequence of early detachment, however, nothing has yet been definitively proven. The strong or excessive affective link with the mother and with the owner (in oriental breeds) may also be part of the explanation.

Treatment

Treatment of pica and wool sucking includes a mix of the following strategies:
- in some cases merely keeping the pet away from items is useful.
- making items aversive with unpleasant smelling or tasting detergents: garlic or red pepper mashes, aloes, quinine, strong perfumes (avoid chlorinated agents which attract cats)
- redirect the cat to other items: increasing feeding opportunities through the use of feeder type toys may help.
- keeping the materials out of reach *(Houpt, 2005)*, when possible
- offer derivations to the cat, such as toys, possibilities to go out for a walk or a hunt
- behavior modification, creating a predictable and reliable environment avoiding anxiety sources
- restructuring the interactions with the owner, by discouraging over-attachment syndrome (regular and increasing separation phases from the owner, compensated by physical contacts initiated only by this latter while ignoring cat solicitations: it is hard to get observance but it is efficient)
- in some cases use psychotropic medication e.g. a Selective Serotonin Reuptake Inhibitor (SSRI) such as fluoxetine or a tricyclic antidepressant (TCA) such as clomipramine *(Luescher, 2002)*.

Because Siamese and Burmese cats are over-represented up to 8 months of age; a genetic predisposition toward wool sucking is suspected but not yet proven.



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> Fixation on one type of food and neophobia

Neophobia is the opposite of neophilia and corresponds to avoidance of a new food compared to the usual food. Also called "fixation of food habits", neophobia has been identified in cats. This behavior is part of a food selection strategy.

Omnivorous animals consume foods that provide a balanced diet and avoid taking the risk of eating new unknown foods. However, carnivores in the wild display more neophilic than neophobic behavior *(Thorne, 1982)*. Neophobia is more common when meals are served in unusual conditions *(Thorne, 1982)* or if the animal is under stress *(Bradshaw, 1991)*.

It is not uncommon for a cat to become fixated on a particular type or flavor of food and reject all others. Often this can be prevented by offering a diversity of flavors and textures of appropriate complete and balanced diets when the cat is young. Willingness to try new foods and food preferences may be influenced by the queen and the weaning conditions: kittens fed since weaning with the same cere-

al-based food preferred this type of food to more palatable canned food with tuna *(Wyrwicka & Long, 1980)*. Neophobia, the lack of recognition of food as being edible *(Bradshaw et al, 2000)*, exists in varying degrees. The more regular the diet, the more persistent is the neophobia.

In some cases it may be medically necessary to switch a cat to a new diet. If the diet texture and shape are the same as the previous one, the cat may accept it readily by adding it step by step in the new food while decreasing the proportion of the old food over a week of time. For some cats, offering the new food and old food side by side will also help the transition. In other situations, a cat may need to be transitioned from a canned food to a dry food or vice versa. This is often difficult since many cats seem to have preferences for certain shapes and/or textures of food. Increasing the smell may enhance eating for some cats and this often can be accomplished by warming the food.

A few days are required to overcome neophobia and for an animal to experiment with the new food *(Cheney & Miller, 1997)*. To overcome neophobia towards a new flavor, cats should not be exposed to the smell alone; they must also taste it. In a study on cats, *Bradshaw* (1986) showed that neophobia disappeared after the third day of presentation of food flavored with lamb. Neophobia reappeared three months later if the cat was not regularly exposed to the new flavour. One solution devised to overcome neophobia towards a flavor involves using drinking water as a support. Although neophobia toward new foods is common in many species, neophobia toward flavored drinking water is indeed rare.

Introducing a new diet under unusual circumstances or when a cat is stressed (by pain or illness, by being away from its owner, in a veterinary clinic etc) is more likely to result in neophobia (through an aversion learning process) than if the new food is introduced under familiar, positive circumstances. It is recommended to always introduce a new diet under the least stressful conditions for the pet and use a food transition program.

THREE APPROACHES WHICH MAY HELP OVERCOME NEOPHOBIA

1 - Offer the new diet each day for at least three days (offering fresh food each time). Persistent exposure, even if the cat initially refuses the new food, may help overcome neophobia.
2 - Try putting a small piece of the new food in the cat's mouth, so that the cat can taste the new food.
3 - If the diet is a wet food (can or pouch), try smearing a little of the food onto the cat's front legs. Most cats will lick off the food and this can habituate the cat to a new food.

> Learned taste aversions

Aversion is a strategy used by animals to avoid foods that are unsuitable for them. It is a form of negative conditioning. If the smell of food is associated with distress, with an unpleasant experience (hospitalization, forced or hidden drug administration) or with a digestive problem (poisoning, allergies), the food will be avoided in the future. This phenomenon is known as aversion *(Cheney & Miller, 1997)*.

In cats, aversion sets in very quickly. A single meal associated with unpleasantness leads to a refusal to eat. Such aversion can persist for 40 days *(Bradshaw et al, 1996)* or more *(Mugford, 1977)*. The smell alone of a food associated with digestive disorders is enough to elicit aversion. Cats even go so far as to show aversion for their usual food if it is served in the presence of an air current bearing the odor of a food to which they have developed an aversion *(Mugford, 1977)*. Be careful when preparing foods for cats being boarded at the hospital. Odors may travel and could trigger an aversion reaction even in cats being fed their usual diet. It is best to prepare the food in a place where food odors cannot reach the cats.

► Quantitative disorders

> Polyphagia

It is crucial to remember that feeding is an affective and rewarding act for the owner. It is the moment of the day during which the owner can get attention from the cat. However owners have to understand that the dietary behavior of cats is different from humans. For humans, the kitchen is often a social place. Cats like contact and will therefore go to the kitchen just to share social interactions. These requests for interaction are misinterpreted by the owner as begging for food. Owners do not recognize food soliciting behavior as an attention seeking behavior, not hunger and provide the cat with too much food which it willingly consumes. Most cats

TABLE 5 - CREATING GOOD FEEDING AND EATING HABITS IN CATS

1. Pick a diet appropriate for the life stage (kittens, adult cats, elderly cats), physical activity and environment
2. Provide food in an appropriate bowl in a safe, secure, quiet location
   a. When multiple cats reside in the home each cat should have their own bowl
   b. If social conflicts between cats are evident then some cats may need to be fed in separate locations
3. Calculate the appropriate amount needed to meet the nutritional needs of each cat in the home
4. Feed close to the same time each day
5. Avoid excessive solicitations for food if nutritional needs have been met
   a. Substitute play time, exercise, grooming or attention rather than supplementing dietary intake

TABLE 6 – CAUSES OF POLYPHAGIA
From: Masson, 2004

Transient			Persistant	
Reactional		Induced	Weight gain	Weight loss
Physiological	Psychological	Orexigen drugs	Dysregulation	Metabolic
Gestation Lactation Cold temperature Sustained exercise	High palatability	Megestrol Acetate	Hypothalamic lesions (unusual)	Diabetes mellitus Hyperthyroidism Malassimilation Chronic kidney disease
	Owner solicitation	Glucocorticoids		
		Anticonvulsivants		

are obese because they are provided with a highly palatable, energy rich diet in excessive of their metabolic needs. Starting out with a good feeding routine and pattern may help prevent obesity **(Table 5)**.

It is important to remember that neutering is responsible for decreasing energy expenditure. The balance between energy intake and energy requirements is usually disturbed after neutering.

Pathological and medical reasons

If the cat consumes excessive amounts of food without gaining weight then a metabolic problem (such as hyperthyroidism, pancreatic insufficiency, diabetes mellitus), massive parasitism or sometimes brain tumors, should be considered and a full medical evaluation obtained.

Some drugs such as diazepam, megestrol acetate and corticosteroids may also induce polyphagia **(Table 6)**.

"Hypersensitivity / Hyperactivity syndrome"

Some European behaviorists recognize a syndrome of excess food intake which may be due to lack of self control. Kittens scratch, bite, run everywhere and play constantly. Owners are impressed by the amount of food eaten without becoming fat. Some cats gulp their food, eat it quickly and then regurgitate it. This syndrome is due to a lack of mother regulation between the 5th and 6th week. This often happens when adopting young kittens from an outdoor life, that are not handled and not well fed during this crucial period of their life *(Beata, 2007)*.

Social problems

A cat may consume large quantities of food if it is anxious due to overcrowding, tense social relationships between cats in the home and lack of privacy while eating. Some kittens coming from large litters can maintain the habit to overeat to compensate for competition to the access of food, even when they are later in a single cat household, without competition.

If the problem of excessive food consumption is due to social problems between cats within the home, some simple environmental manipulations can be useful. Food and water bowls should be provided in all areas of the home, after paying special attention to which cats frequent what areas and where they spend their time. Some cats may be more agile than others and the provision of food bowls on elevated locations may allow them to eat with privacy. If one cat consistently eats more than its share of food, then set feeding times and separating cats for feeding may allow all cats to eat their required allotment.

Anxiety

The cat that is permanently looking for food may meet the European criteria for bulimia which can be a symptom of permanent anxiety. The excessive eating and food seeking are a substitution activity for frustration or conflict. If anxiety is the source of overeating then the individual conditions causing anxiety must be addressed (changes in schedules or territory organization, etc.).

These treatments are beyond the scope of this article but are detailed in other sources *(Horwitz, et al, 2002)*.

Excessive food solicitation behaviors and overfeeding

When cats become hungry they may engage in bothersome food solicitation behaviors. These can be especially problematic if the cat does not have access to the outdoors to hunt, or if food is provided in a meal format or set amount daily to prevent obesity. In an attempt to get noticed, food solicitation behaviors include vocalization, climbing, jumping, running, even destruction or agressivity (especially when meal feeding is chosen vs ad libitum distribution, creating some food frustration). Often these behaviors occur during night time hours, waking their owners. In an attempt to placate the cat many owners will get up and feed the cat. Unfortunately, although the cat will stop bothering the owner after being fed that time, the act of feeding the cat when they are noisy will result in the behavior continuing since the cat has been successful, i.e. they received food. The reward (food gift) is indeed reinforcing the undesirable behavior.

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Figure 9 *- Examples of food dispensing toys.*

Owners need to be counseled on how to avoid giving into demands for additional food. First, they must realize that not all vocalization (even that which occurs in the food preparation area) is a request for food. In some cases, it is just a request for interaction such as petting, grooming or play. A lot of owners wrongly interpret some marking behaviors (such as rubbing against the legs) like begging and they fill the bowl! They will effectively think they were right because they see the cat grabbing some kibbles in a very short meal. This will install a nibbling feeding habit in the cat that can eventually facilitate the development of obesity. If the owner responds to these solicitations with food, then food solicitation behavior can become a ritual, helped by the same reinforcement process explained in the previous paragraph.

Feeding the cat on a set feeding schedule allows owners to control food intake. The daily amount provided should be calculated so that the proper amount is fed daily. In some cases providing the food in a food dispensing toy **(Figure 9)** will slow down the rate of consumption and perhaps increase satiety thereby helping to decrease food solicitation behavior.

Daily play sessions limit the risk of obesity. Research has indicated that cats may quickly tire of a toy and the intensity of play diminishes within a few minutes. However, the presentation of a new toy stimulates the return of play *(Hall et al, 2002)* **(Figure 10)**. Exercise can also be increased by placing food bowls at distant locations requiring the cat to walk longer distances to obtain food.


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Figure 10 *- Cats need to be stimulated by new toys to encourage play behavior.*

Globally, two methods are employed to stop excessive food solicitation behaviors:

1. to ignore the cat and stop feeding the cat on demand, a process called **extinction**. When the owners attempt to do so, the cat will usually escalate their attempts for a few days, before it decreases. This intensification phase is hard to manage for owners. They

must be aware of such process and must hold out. With time, they will finally see a decrease in the demands. To facilitate success in this intensification phase, the owners can also either confine the cat to an area where they cannot hear it, or interrupt the behavior with a noise stimulus that discourages the cat from continuing.

2 to provide food in a way that is not connected to the owners using **a timed feeding system.** Electronic feeders that operate on a timer can be programmed to provide food at a set time each day and the cat may learn to wait until that time to be fed. In other cases, the feeding time must be slowly manipulated to teach the cat to eat at a later time each day.

Habits have to change to stop the reinforcement process. The owner may change the meaning of some daily situations or clues to play, petting, walking etc.

> Finicky eating patterns

Many pet owners complain that their cat is finicky and eats poorly. While many medical problems can influence hunger and subsequent food intake, these will not be considered here. Only the behavioral issues will be discussed, although all cats with suspected diminished appetite should undergo a complete medical and dental evaluation.

In certain cases a cat may refuse food from time to time simply because they are overfed, not hungry and/or exercising self-regulation of intake. Many new owners are unaware of the nibbling pattern of cat feeding behavior. Other cats may show finicky behavior due to excessive rotation of dietary choices. In other cases the cat has learned that waiting and not eating will result in a different, perhaps more desirable food choice being offered. It is important to take time to explain that too many changes in food varieties or giving treats can be harmful for cats.

The first step is to evaluate the actual amount of food provided daily and the actual amount consumed by the pet. This must also include all treats and human foods provided to the pet. The pet must be weighed: cats that are of normal weight and maintaining their weight over time are usually consuming adequate nutrition to maintain body weight. Body condition score should also be assessed. If the cat is obese then finicky behavior is not a nutritional problem, rather an emotional and behavioral one.

Body weight of a finicky cat should be assessed. If the cat is obese and if no disease is suspected, you can hypothesize that the cat may obtain food from additional sources (perhaps from a neighbor, another pets food etc).

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Once any underlying medical and dental problems have been identified and treated, behavioral treatment strategies can be employed. Daily caloric needs should be evaluated so that they can be met. The appropriate amount of food that should be provided daily to meet the animal's nutritional needs should be calculated for the owner. Often this is less than the owner has been feeding and this simple reassessment can help the owner understand that the cat is consuming adequate amounts of food. For many animals, setting a feeding routine is useful. The food should be provided at the same time daily in a quiet location and with each cat having its own bowl. Limiting treats can also help increase the desire to eat the provided commercial preparation.

Feeding diets that have increased levels of fat will allow for more nutrition with each mouthful. Excessive attention at meal times should be avoided since this can increase finicky behavior if it becomes an attention seeking tactic. Regular fol-

low up both to weigh the pet and discuss progress with the owner should be scheduled to assess improvement and keep the treatment program on track.

> Anorexia

Anorexia is defined as a diminished appetite. It is associated with many disease processes, trauma and psychological disturbances. In complete anorexia the animal does not eat at all. In partial anorexia the animal may eat some food but not enough to meet its metabolic requirements. Although it is often the reason for consulting the veterinarian, anorexia can result from either an organic or behavioral pathology. It can be due to:

- illness such as fever syndromes or cancer (anorexia may appear before tissue destruction and is the result of tumor metabolites).
- any parodontel disease (creating pain), face or jaw trauma (leading to an inability to eat)
- loss of olfaction: anorexia will last as long as the olfactory mucosa is not restored (renewal needs 4 to 5 days after the destructive agent has been removed)
- psychological stress (depression in reaction to the absence of the owner, even loss of close companions) or physical stress (e.g. excessive handling) *(Beaver, 2003)*: anorexia is accompanied by behavioral escape and withdrawal, house soiling, inhibition of play and exploration.
- anxiety triggered by social stress (antagonistic relationships between household cats, schedule changes, new household members (human or animal)
- anxiety that occurs with transportation, boarding or hospitalization (which can lead to specific learned aversion associated with the diet given during the event).

Cats that are anxious may hide and refuse to come out to eat. In this situation, the anorexia may simply be due to a lack of access to the food bowl. In some individuals anorexia may last only a few days, resolving when the stressful event ends or within a short period of time (2 to 3 days after boarding, house move, or transportation). Often these individuals do not need intervention other than providing easily accessible food and water bowls, possibly located where the cat is hiding. They then compensate by a huge meal. Forcing the cat to come out of hiding to eat is counter productive and may increase rather than decrease anxiety and the resultant loss of appetite.

In multiple cat homes partial anorexia may be ongoing especially if the social situation creates anxiety, stress and aggressive encounters between cats. If food and water bowls are not placed through out the environment, some cats may be unable to access them except at odd times. Even then, they may risk being attacked by other cats within the home for entering their territory. Understanding how the cats use the space provided to them and where various cats spend their time within the space provided can indicate where food, water bowls and litter boxes should be placed. Owners may need to be educated on aggressive interactions between cats. Not all aggressive interactions are overt (hissing, growling, chasing and fighting) but in many cases the actions are covert such as staring, blocking access or displacing the cat from resources **(Table 7)**.

In cats that are anorexic for more than 4 to 5 days, early intervention is suggested. Meal feeding in quiet, dark locations may help some individuals. The use of pheromone diffusers may calm some cats and increase food consumption both in the home and in the kennel or hospital situation, by their appeasing effects. *Griffith et al* (2000) found that both well and ill cats exposed to the pheromone showed increased interest in food and eating and increased grooming. In the second phase of the

Table 7 - Social stress in the domestic cat and its effect on behavior

Problem	Effect	Solution
Too many cats in the home	Social stress leads to problems with eating or access to the feeding bowl	One food bowl per cat in various locations
To little space for so many cats	Aggressive interactions and/or hiding possible	Create additional vertical space
Aggression between cats	Chasing, injury, hiding, weight loss due to lack of access to food or anxiety	Create separate territories for cats, perhaps with barriers Have adequate resources through out the environment
House soiling	Owner distress, relinquishment of cats	More litter boxes in multiple locations (hygiene?)

same study, cats exposed to the pheromone and a cat carrier showed significant increase in food intake over 24 hours compared to cats exposed to pheromone alone. Providing secure quiet locations, hiding spots within the cage or kennel and pheromones may therefore help increase eating in some hospitalized and kenneled cats.

When anorexia becomes profound, medical intervention is required. In the early stages some individuals may respond to benzodiazepines which may stimulate appetite. Diazepam however has only a transient effect (3 to 4 days) and acute hepatoxicity is often a serious risk. Mianserine has a quick orexigenic effect, but leads to some desinhibition to be controlled *(Coupry, 2007)*. Food should be nearby after administration in case the cat shows interest in eating. Cyproheptadine has also been used in some cases to stimulate appetite. Progestins and anabolic steroids have been tried in the past but, due to potential adverse side effects, they are not recommended and rarely used. Should anorexia persist, enteral feeding tubes need to be employed to allow for supplemental nutrition until the cat recovers and begins to eat on its own. Forced feeding presents however a disadvantage: digestion and absorption are indeed incomplete compared to voluntary eating (food intake stimulates the cephalic phase of digestion which can account for up to half of the gastric acid production).

To summarize, the following simple actions can help solve the problem *(Rabot, 1994)*:
- pay attention to any causes of uncomfort (dirty bowl, noisy place, strong smell of litter box, feeding spots with frequent passage, air flows)
- warm the food to 38-40°C (instead of receiving the canned portion directly out of the refrigerator)
- move the bowl to a quieter place (by looking at the cat activity program and locating preferred spots) or separate each cat (to avoid rivalry), at set times
- introduce a novel and very palatable food (the effect only lasts 2 to 3 days), in a sudden way, or spread over several days by increasing proportions into the daily ration
- attend meals for strongly dependent cats or put some food on the fingers to make them linked (especially in the case of reactional depression, but beware of the risk of ritualization)
- ensure renewal of canned food (to avoid oxidative and bacteriological damage).

One must remember that the efficacy of these recommendations may vary between cats and situations. Felines are rarely deceived and often stubborn.

In a multiple cat home food and water bowls must be spread through out the environment so that all cats may access them easily without encountering cats that they have a conflict with. In many cases this will resolve the anorexia and the cat will begin to eat normal amounts of food.

5 - Water drinking in cats

Perhaps because of their evolutionary history, cats tend to have a relatively low intake of water. *Felis lybica*, the European cat ancestor, lived in the desert and was able to concentrate its urine to avoid water losses. Today's cat has kept this ability, but with the risk of forming bladder calculi. Although a cat can be food deprived for several weeks, a few days of water deprivation are enough to put its life in serious danger.

© Y. Lanceau/Royal Canin - Maine Coon

Animals have three sources available to meet their water needs:
- water offered for drinking
- water in the food
- water created by the metabolism of nutrients *(Beaver, 2003)*. Water is produced by substrate oxidation (fat providing the greatest quantity but carbohydrates providing the best output).

► Some pathophysiological considerations

Water needs for cats vary from 55 to 70 mL/kg BW/day. The requirement is in fact related to the dry matter intake: 2mL per gram of dry matter eaten.

> Intrinsic regulation of drinking behavior

Thirst is the sensation which triggers water intake. The signal comes from the lateral hypothalamus, close to the hunger center. Regulation is complex and closely linked to variation of plasma osmolarity, controlled by vasopressin.

Drinking satiation is first triggered by oral stimulation on a short term basis (one hour). Gastric distension interferes later, acting mainly on the frequency of intake. Finally, cellular hydration controls water satiation through complex interactions.

Cats are not as sensitive to water loss as the dog and may not drink additional water until they have lost as much as 8% of their body water *(Case, 2003)*.

Water intake varies depending upon water losses:
- physiological losses: urination (40mL/kg/day), feces and respiration, lactation
- pathological losses: diarrhea, vomiting, edema, skin injuries, diabetes mellitus, renal failure, etc…

A reduction of blood pressure and blood volume also provoking thirst, through the renin-angiotensin-aldosterone system.

> External factors that influence drinking behavior

The composition of the food

Water intake is affected by food type and moisture content. Cats fed a canned food drink virtually no water since they meet most of their water requirement with their food intake. It is the same with fish or meat fed animals.

Dry food contains only 7-8% water, requiring the animal to consume more water to meet their daily needs. It has been shown that dry food increases fecal water loss but decreases urinary loss *(Jackson & Tovey, 1977)*. However, it is important to mention that, while intake is strongly modified, the general water balance is not modified by the moisture content of the food. Urinary calculi are more strongly linked to the urinary mineral composition and urinary pH than to the moisture content of the diet. The only risky situation occurs when there is a transition from canned to dry diet.

Caloric density does not affect water intake. Increasing the dietary protein level results in increased water intake (due to the increased diuresis required to eliminate urea). Carbohydrates decrease water intake, due the higher output of metabolic water from carbohydrate metabolism. Sodium chloride increases water intake. Hypernatremia (> 160 mEq/L) triggers thirst and water consumption in cats.

Temperature

The drinking behavior of the cat is much less influenced by temperature and effort compared to the dog. This can be readily explained as salivary and perspiration losses are not significant in the cat. To facilitate water intake the temperature of the water must not be too cold (not less than 10°C).

Food supply

This factor has been better studied in dogs than in cats. In a restricted regimen, the rate of water intake increases to 2.5 mL per gram of dry matter eaten. A one hour per day feeding pattern leads to a decrease of food and water consumption, compared to the ad libitum situation. In this latter context, water intake is linked to the meals. This is a learned process.

► Practical considerations to encourage a cat to drink

Like food intake, cats drink throughout the entire twenty-four hour period. They drink 12 to 16 times a day but water intake each time is small: 10 to 12 mL. Tremendous variation exists between individuals: this is linked to the sum of physiological effects described above.

To help promote optimal water intake, cats should be provide with fresh, clean water daily from easily accessible water bowls. Owners must pay attention that their cat can have access to water at any time. It is dangerous to provide only one bowl in one room, which could remain closed for a period of time, thus preventing the animal to drink enough. A second bowl elsewhere in the house is recommended, particularly when leaving the cats unsupervised e.g. for a weekend.

Spoiled water is rejected by cats. Glass, metal or porcelain bowls are preferred to plastic ones. The location of the water bowl is important: it has to be put at least 50 cm away from the food bowl and the litter. This distance is sometimes critical when the cat is hospitalized. Water must be palatable: cats are extremely sensitive to odors and some can display preferences for water taken from toilets, sink, etc. Some cats prefer electronic water fountains that aerate the water on a regular basis. One way to increase water palatability is to add meat juice, some milk or some salt. Feeding either a canned food or a liquid food is another alternative.

► Drinking disorders

> Adipsia or hypodipsia

Any cause of hyponatremia (such as severe hepatic disease, congestive heart failure, acute kidney failure, nephrotic syndrome) can stop water intake. These causes of adipsia are in fact compensatory mechanisms.

Conditions of the oral cavity (gingivitis, abscess, tumors, ulcers, fractured jaws, foreign bodies, etc.) may reduce drinking, due to either mechanical or painful reasons.

Adipsia may be simply the result of poor water quality (e.g. water left too long in a dirty bowl). It is nevertheless important to remember that water intake will be still nil as far as all water needed will have been supplied by the food!

> Polydipsia

The average water consumption of a cat depends on the dry matter ingested: around 2mL of water is required for each gram of dry matter consumed.

Any change of drinking behavior must be carefully evaluated. Water intake becomes pathologic beyond 100 mL/kg/day. Any cause of polyuria (> 50 mL/kg) will logically lead to polydipsia **(Table 8)**.

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Plasma osmolarity facilitates the identification of what is primary polydipsia and what is compensatory *(Remy, 1986)*:
- if plasma osmolarity is greater than 310 mOsm/L, polyuria is primary and urinary loss creates polydipsia
- when plasma osmolarity is below 290 mOsm/L, polydipsia is primary and the low osmotic pressure leads to polyuria.

Intake of salty foods (fish scraps…) leads to polydipsia, and then to polyuria.

Polydipsia may be a reaction to stress or a substitution activity of a permanent anxiety. Hypercortisolemia triggers excessive water intake *(Landsberg, 2003)*. Situations of conflict situations must be identified and corrected.

Hypercalcemia linked to secondary hyperparathyroidism can stimulate thirst.

Table 8 - Differential diagnosis polydipsia
From: Masson, 2004

Cause and intensity	Urinalysis		Blood analysis		
	Osmolarity	Abnormal elements	BUN	Glucose	Other
Chronic kidney disease +	⇩	Protein	⇧	N	
Pyometra +	N	Protein	⇧	N	
Diabetes mellitus ++	⇧	Glucose	N	⇧	
Diabetes insipidus +++	⇩		N	N	
Hyperadrenocorticism ++	N		N	Slight ⇧	Hypercortisolemia ⇧
Hyperthyroidism ++	N		N	N	
Liver failure ++	N	Bilirubin	N or ⇧	N or ⇩	SGPT ⇧
Gastro-enteritis +	⇧		N or ⇧	N	
Hypercalcemia +	N		N	N	Calcium ⇧

N = no change

Hepatic failure can lead to polydipsia through decreased renin degradation and increased angiotensin activity.

Conclusion

The data presented provides an understanding of the normal eating patterns of domestic cats. Some of the information is empirical. Others come from research, in both the natural condition and in the laboratory. Extrapolation from other species and large felids should be avoided.

The data can help veterinarians and pet owners make relevant choices for feeding routines and food types. The domesticated way of life, with increased social relationships and and evolutionary predator behavior must be considered when designing feeding protocols.

Medical problems can often contribute to changes in the selectivity and regulation of food ingestive behavior. Obesity is a major feline health problem. Proper client education and feeding regimes can help prevent and control excessive weight gain. The opposite problem of the fussy or finicky cat is only a problem if the cat is loosing weight. The real issue is in the owner's mind and belief.

Behavioral problems related to feeding and drinking can be due to anxiety, inappropriate provisioning of the cats within the home, learned eating patterns or compulsive disorders. A complete medical and behavioral evaluation should enable the clinician to determine the cause of the problem and therefore prescribe appropriate intervention.

Although the integration of the cat into the family can bring well being and happiness to everyone, the veterinarian will also have to explain to owners to avoid "thinking too human" when taking care of the cat, especially when feeding.

Frequently asked questions about the feeding behavior of the cat

Q	A
Do cats need to have several different flavors?	No, as long as they have a well-balanced diet, cats do not need flavor variety from day to day.
Why are cats fussier than dogs?	In fact, cats are not fussier than dogs. This commonly held belief is untrue. A poorly reared dog may be very hard to please. For some dogs, refusing food is a way of asserting their position in the family. Cats on the other hand, attribute no "social" value to food. If they refuse to eat, it's either because they're sick or because they have a genuine dislike of the food. The competition that exists in a pack always lead dogs to gulp down a maximum amount of food in the shortest possible time, i.e. dogs display "gluttonous" behavior. Cats, as solitary hunters, can take their time to dissect and savor their prey. Their behavior can be described as "tasting".
Are cats sensitive to sweet and salty taste?	Cats are different from dogs and humans. Cats have no preference for sweet tasting foods. This is due to their strictly carnivorous nature. Cats are also less sensitive to salt and have a higher NaCl or KCl detection threshold. Since salt is found naturally in their prey, cats have not been selected for this gustatory capacity present in other mammals, especially herbivores.
Every time I go to the kitchen my cat follows me and cries, what does he want?	Often the most frequent location and time for the cat to interact with the owner is around feeding so they may also choose that location or time to solicit attention. If the cat has been fed and consumed the proper amount to meet their nutritional needs, then they should not be fed when they vocalize. Feeding the cat every time it vocalizes will be seen by the cat as a reward for their behavior and therefore vocalization will increase. Try substituting play, grooming or social interaction rather than feeding the cat when it is not feeding time.
I have two cats and one is overweight and one is not. How can I provide an appropriate diet for each cat?	Each cat may need a different diet to meet their nutritional needs. One solution is to use timed meal feeding. Several times a day each cat is provided their diet and given a certain amount of time to consume their food. To facilitate each cat eating the appropriate food, the cats should be separated during feeding time. Once feeding time is over, the bowls should be put away until the next feeding session. In other situations, the thinner cat may be more agile than the larger cat and can have their food bowl in an elevated location that the heavier cat cannot access.

Q	A
"How should I react when my cat refuses to eat the prescription diet?"	Transitions to a new diet are best done slowly. The new diet can be offered next to the old diet to help the cat become familiar with the new food. In some cases it might help to mix the food together. If the texture of the two foods (old and new) are very different, this may be a problem for some cats. Using a similar texture food if possible may help the transition.
"How can I prevent my cat from hunting birds?"	Although unwanted by humans, predatory behavior is a normal cat behavior. Keeping the cat indoors will prevent predation. If that is not possible, some cats will be deterred by wearing a quick release cat collar that is equipped with large bells to warn the birds of their impending approach. Naturally, removing temptation in the form of bird feeders and bird houses is prudent.
"I need to increase the amount of liquid (water) that my cat ingests every day. How can I do that?"	Water consumption will vary according to the food type provided. Cats on dry kibble diets will drink more water than cats on moist, canned food. Water consumption can be increased by adding water to the canned food or providing water that has been enhanced with fish flavoring. Some cats prefer water that is fresh and aerated and will drink more water if provided water from a running faucet or a pet drinking fountain.

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Palatability and nutritional precision are interconnected

Palatability is essential if the cat is to take in what it needs. The best-balanced food in theory is useless if the cat turns its nose up at it. Even more so when its health demands a special diet that is theoretically not favorable to palatability: limited sodium, fats and proteins. There are various solutions for overcoming this obstacle and retaining an adequate palatability level.

Palatability is not a luxury: it's a vital obligation

The fundamental aim of nutrition is to provide all essential nutrients every single day in a sufficient quantity to cover all needs. The first of these needs is energy, in whatever form the calories are provided.

The formulation of feline diets is above all based on energy density: the ration volume offered to the cat must be compatible with its capacity of digestion:

- too low a volume does not give the cat a feeling of satiety
- too high a volume may not be consumed properly or may cause digestive problems.

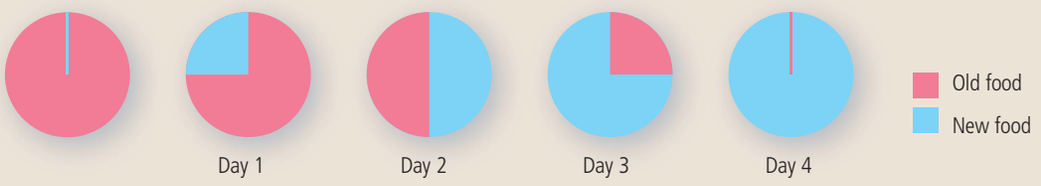
Palatability helps the cat overcome certain kinds of stress

For many cats, a loss of appetite is one of the first signs of stress. If the food is not sufficiently palatable and if the period of stress is prolonged, there will be a risk of chronic underconsumption and the appearance of nutritional deficiencies. The cat will lose weight, the quality of its hair will deteriorate and its immune defences will be weakened.

Examples of situations in which the cat's appetite is disturbed

- Changes of environment: when a kitten or an adopted cat arrives in a new home, moves house or is put in a cattery during the holidays.
- Changes to diet: some cats tend to reject a new food (neophobia). This phenomenon is especially observed when the food is offered in unfavorable environmental conditions or when cats have been given the same food for a very long time. Conquering neophobia entails realizing the most gradual dietary transition possible **(Figure 1)** in conditions that are ideal for the cat's well-being, thus preventing the development of an aversion that would be even more difficult to overcome.

FIGURE 1 - TECHNIQUE TO ENSURE GOOD DIETARY TRANSITION



It is advizable to change a diet gradually. For example, mix 25% of the new food with 75% of the old food on day 1. The next day mix together equal quantities and on day 3 mix 75% of the new food with 25% of the old food. On day 4 you can give the cat only the new food.

How is palatability evaluated?

Palatability is measured through objective studies to assess the cat's behavior in the presence of one or several foods. It is mostly interesting to try to estimate the cat's preferences and the way the food is ingested.

The cat's preference for a given food

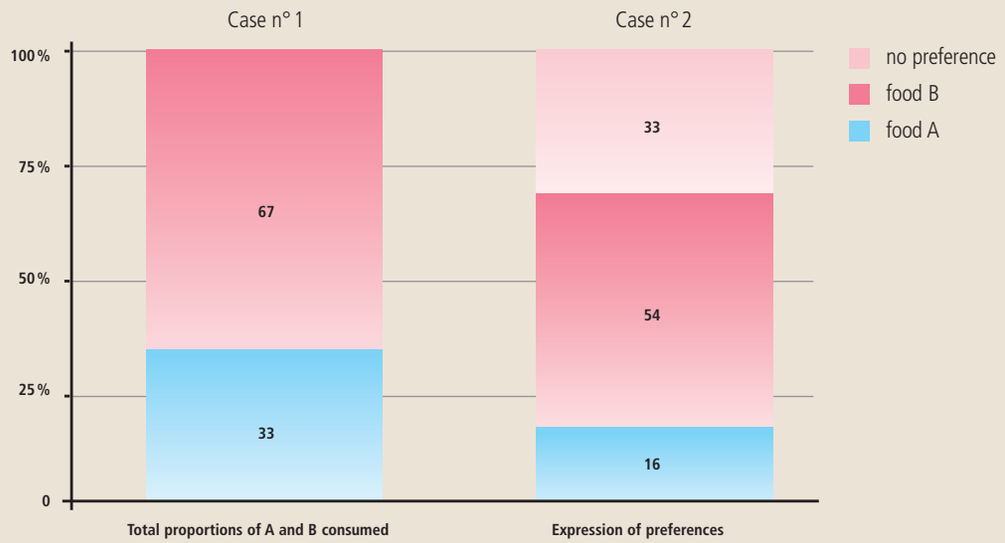
This can be realized by measuring the respective consumption of two different foods freely available to the cat (Figure 2). The cat's selection criteria are subsequently analysed. The reliability of the result depends on the number of cats used and the duration of the study among other things. The selection of the most discriminating cats helps increase the sensitivity of the tests.

The way the food is ingested

This reflects the attractiveness of the food for the cat. The quantity of food spontaneously ingested within a given time or the time needed to ingest a given quantity are important data. Videos showing the prehension method and any consumption difficulties provide some useful additional data.

The information obtained at the cattery is confirmed by studying cats owned by private individuals when evaluating palatability in diverse environmental conditions and taking into account such notions as the owner's appreciation of the look of a product and his or her attitude when serving the food, the variable conditions of serving a meal, etc.

FIGURE 2 - TWO DIFFERENT WAYS TO EXPRESS THE RESULTS OF PALATABILITY



The results can be expressed in two ways:
- Case n°1: the graph only indicates the proportions of foods A and B consumed by all cats.
- Case n°2: 16% of cats preferred food A (i.e. they consumed at least twice as much of food A as they did of food B), 54% preferred food B and 33% showed no preference.
The second method best reflects the differences, because it takes into account the number of cats that show a clear preference.

Does palatability diminish with time?

All food products tend to deteriorate with time. Guaranteeing good palatability during the whole shelf life of a product entails slowing down the aging of the product.

Quality of fats

The conservation of the fats in a food demands close monitoring, particularly those in the kibble coating. In contact with the oxygen in the air, the fat molecules generate the production of unstable molecules – free radicals – that cause oxidation. Liquid fats at ambient temperature (poultry fats, vegetable oils) are the most sensitive to oxidation, because they are unsaturated. Keeping food in the light at a warm temperature accelerates the process.

The role of antioxidants is to block the free radicals before they provoke chain reactions that lead to the appearance of peroxides, then secondary oxidation compounds, aldehydes and ketones. All of these compounds are potentially toxic. It is rare for the cat to consume a food that contains deteriorated fats however, as it is very sensitive to the rancid smell emitted by oxidation. The use of truly effective antioxidants is indispensable to conserve palatability and protect the health of the animal.

Development of the aromatic profile

Expertise on palatability is not restricted to the development of aromas that are particularly attractive to the cat. These aromas are essentially volatile, so they can be easily picked out by the cat's sense of smell. That means they risk evaporating in the ambient air. As a result, the kibbles internal odors come to the fore. The cat does not necessarily find this different aroma profile as pleasant.

Another risk is the deterioration of aromas with time. What starts out being a pleasing flavor may ultimately turn into a negative palatability factor.

The research carried out on palatability entails following the development of these substances to verify their behavior as the product ages. Palatability must remain satisfactory throughout the life of the product, right up to the best before date on the pack.

To limit the risk of the loss of palatability after the pack has been opened, it is important to select the right size of pack for a particular cat's daily consumption. A 4 kg cat that eats an average 50 g of kibbles per day, consumes the equivalent of

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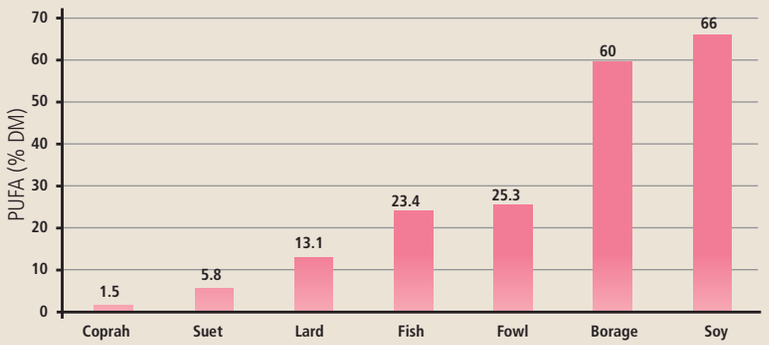
The quality of fats is monitored in the ingredients and in the final product. The freshness and the resistance to oxidation of oils and fats are major criteria for good palatability.

FIGURE 3 - COMPARISON OF THE QUANTITY OF POLYUNSATURATED FATTY ACIDS (PUFA) IN DIFFERENT OILS AND FATS



The higher the PUFA content and the longer the fatty acid chains, the greater the fat's sensitivity to oxidation if not adequately protected.

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The role of all the antioxidants is to stabilize the fat in the product and the kibble coating to preserve palatability and the health of the cat.

a 1.5 kg (3 lb) bag in a month. The aromas will be conserved well during that period as long as the bag is stored in a dark place in a hermetically sealed container at a stable temperature. It's better not to select a larger bag as this would require a longer period of storage.

Working on conserving the nutritional qualities of the product

The preservation of a product's organoleptic qualities entails vigilance at various levels.

The choice of ingredients

Palatability must be a key factor to take into account from the moment of formulation. The thermal treatment used to separate proteins and fats from a meat has an impact on palatability for example. Likewise, a given source of fat will be favored depending on its resistance to oxidation **(Figure 3)**.

The process

All the technology involved in kibble grinding, cooking, drying and coating is oriented to preserving the original qualities of the ingredients. The time between manufacture and packing is minimized.

Antioxidation

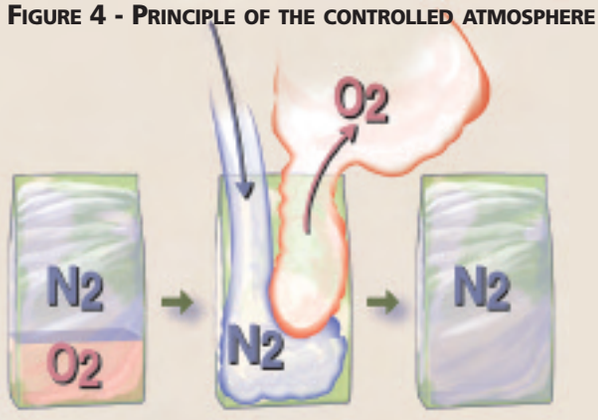
To prevent the oxidative reactions from beginning, it is preferable to use chelated trace minerals (especially iron and copper). Once chelated, their bioavailability is increased and they are unable to catalyze oxidation reactions in the food.

All fats in the food must be fresh and protected before they are transported and used: substances used in cat food are the same as those used in food for human consumption. They are selected on the basis of their safety and efficacy.

Packaging

To rule out the loss of aromas and oxidation the food is kept in an airtight pack totally devoid of oxygen, a technique called modified atmosphere packaging (Figure 4). The air is replaced by a neutral gas (nitrogen) during packaging. The food conserved in this way is protected as the bag is closed. After opening, the aromas are preserved properly by keeping the bag away from light and humidity at a constant, low temperature.

FIGURE 4 - PRINCIPLE OF THE CONTROLLED ATMOSPHERE



Sealed airtight bag modified atmosphere = NITROGEN

The air is made up of around 20% oxygen and 80% nitrogen. The modified atmosphere in the bag is 100% nitrogen, which prevents oxidation phenomena from taking place.